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Honey bees (*Apis mellifera* L.) are multi-media monitors of chemical exposures and biotic effects. This six-year project has developed an automated system to assess in real-time colony behavioral responses to stressors, both anthropogenic and natural, including inclement weather. It also addressed chemical exposures by measuring the concentrations of volatile and semi-volatile organic chemicals in ambient air and the air inside beehives, persistent pesticides and PCBs in bees and pollen, and radionuclides in bees and pollen. The resultant chemical data set includes locations throughout the Canal Creek, Old O Field, Bush River, J Field, and D Field areas of APG. It also includes off-post sites positioned along transects extending into Baltimore, Harford, and Cecil counties, with additional reference/test sites at Churchville and Worten's Point on the Eastern Shore of Chesapeake Bay. This final technical report provides: 1) a statistical approach for processing honey bee population dynamics data, 2) results of calibration trials for real-time monitoring of colony flight activity, and 3) the chemical exposure/fate data in a comprehensive, searchable database for use by APG installation restoration project managers.

14. SUBJECT TERMS
Biomonitoring, real-time monitoring, hazard assessment, acute toxicity, chronic toxicity, honey bee colony populations, environmental exposures, air quality, terrestrial environment, aliphatic hydrocarbons, heavy metals, military unique chemicals

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FOREWORD

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LIST OF ACRONYMS

AIA	Absolute Ion Abundance
ANL	Adjusted Net Loss (of bees)
ANN	Artificial Neural Network
APG	Aberdeen Proving Ground
As	Arsenic
Be	Beryllium
Ba	Barium
Benz	Benzene
BP	Beach Point Site
BR	Bush River Site
BTEX	Benzene, Toluene, Ethybenzene, Xylene
BRSA	Bush River Study Area
CD-ROM	Compact Disk - Read Only Memory
CGI	Common Gateway Interface
CC	Canal Creek Site
Cu	Copper
CV	Churchville Reference Site
C.V.	Coefficient of Variation
DARPA	Defense Advanced Research Projects Agency
DCB	Dichlorobenzene
DF	D Field Site
DER* DIFF	Derivative-Differential Analysis
Ethbenz	Ethylbenzene
FM	Fort Missoula Site
GS	G Street Site
Hz	Hertz
ipl	ions per liter
JF	J Field Site
JFN	J Field North Site
LC	Lauderick Creek Site (Cluster 13)
mg	milligram
Mg	Magnesium
Napth	Napthalene
ng/mg^3	nanogram per cubic meter
Ni	Nickel
NL	Net Loss of Bees
OF	Old O Field Site
PCR	Percentage Return of Bees
ppt	parts per trillion
QA	Quality Assurance
QC	Quality Control
Pb	Lead
PCE	Perchloroethylene

Rb	**Rubidium**
r^2	**Regression Coefficient**
SSE	**Summed Square of Error**
SOPs	**Standard Operating Procedures**
SSYY MMDD	**File Naming Format: Site, Year, Month, Day**
Sr	**Strontium**
SVOCs	**Semi-volatile Organic Chemical**
TCE	**Trichlorethylene**
TCM	**Tetrachloromethane**
TD/GC/ MS	**Thermal Desorption/Gas Chromatograph/Mass Spectrometry**
TFA	**Tetracholormethane**
Tolu	**Toluene**
USA CEHR	**U.S. Army Center for Environmental Health Research**
VOCs	**Volatile Organic Chemicals**
WP	**Work Plan**
WWW	**World Wide Web**
YC	**Youth Center**
Zn	**Zinc**

EXECUTIVE SUMMARY

The objective of this six-year study was to develop and apply a system of real-time biomonitoring using honey bee colonies to assess toxic chemical contaminants in military-unique, terrestrial ecosystems. The Edgewood Area of Aberdeen Proving Ground (APG) provided appropriate test locations for conducting top down (field to laboratory, colony to individual, effects to exposures) testing. In other words, we used APG as a test bed to examine exposures to chemicals and colony responses to these exposures and other environmental conditions such as weather. Based on the results of these trials, we then moved to more controlled experiments using specific chemicals and field and laboratory dose-response trials.

Extensive annual reports have covered the investigations from 1995-1999, including: 1) measurements of behavioral responses of bees to contaminants, weather and other environmental factors at Canal Creek, Old O Field, J Field, Cluster 3 of Bush River, and at a Churchville reference site; 2) measurements of exposures to volatile and semi-volatile organic chemicals (VOC's and SVOC's) in ambient air and in the air inside beehives to characterize bioavailable (i.e., available for uptake by bees - see Glossary) chemicals at all of the aforementioned sites, at D-Field, and at additional locations near the Boundary of the Aberdeen Proving Ground (APG) and along transects extending more than 20 miles into the communities surrounding APG; 3) measurements of trace elements and heavy metals in forager bees, dead bees, and pollen at every site, and 4) determinations of the concentrations of persistent pesticides, PCBs, and radionuclides in bees and pollen at selected on- and off-post sites.

In 2000, this work was continued at J Field, Cluster 3, and Worten's Point on the Eastern Shore of Chesapeake Bay under a separate contract with Roy F. Weston, Inc. The emphasis for 2000 has been on transitioning the methods developed under the six-year USA CEHR contract into commercial applications and providing the acquired information in a format that can be used to build a framework for incorporating colony behavioral metrics (i.e., measures of effects) and exposures to bioavailable chemicals into a risk framework. This last step is an ongoing collaborative effort, involving personnel from the APG's DSHE Installation Restoration Program, personnel from Roy F. Weston, Company, and the University of Montana, with input from the EPA Biological Technical Advisory Group.

To facilitate this effort and to more fully provide APG Installation Restoration managers with full access to the work conducted at APG since 1995, this final technical report to USA CEHR provides: 1) a statistical method for analyzing flight activity data, 2) a searchable data base including the chemical exposure/fate concentrations for all chemicals (volatile and semi-volatile organic chemicals, trace elements and heavy metals, persistent pesticides and PCBs, and radionuclides), all sites (both on- and off-post), and all sample matrices (ambient air, hive atmospheres, forager bees, dead bees, and pollen), and 3) the results of equipment (i.e., electronic hive) calibration studies using the pesticide methyl parathion to demonstrate that this system is capable of identifying colony responses to exposures to toxic chemicals. Although a single pesticide is not necessarily a surrogate for all other pesticides or other toxic chemicals, it is an organophosphate and therefore similar to a category of common chemical warfare agents. All of this information can be geo-referenced to maps available in ArcView©. Maps and an ArcView© viewer are included with the database.

The data retrieval system was developed using Excel© Spreadsheets that can be linked to an Access© database. The primary objective was to provide program managers with the data in a

format that could be readily accessed by most desktop PC computers. An important criteria was that the database could be used with software already present on most business computers.

The database is available to APG installation restoration managers on Iomega Zip® disks, CD-ROM compact disks, or from our login and password secured file transfer protocol (ftp) web site. For access to the ftp site and to establish a login name and secure password, authorized personnel should contact Mr. Robert Seccomb at seccomb@selway.umt.edu.

This final report includes the database, an inventory of the contents of the chemical exposure database, directions for using the data base, example query scripts, and example output tables listing the highest chemical exposures by year, site, and matrix.

Additional work performed for Roy F. Weston, Inc. is included in a separate report (Bromenshenk, 2001). The Weston report covers the issue of risk assessment, and will be considered a supplement to this report.

PROPOSED ACTIVITIES FOR 2001

This contract terminated May 29, 2001. The emphasis for 2000-2001 has been:

1. Wrap-up of all of the chemical analyses and finalization of methods.
2. Development of the six-year database
3. Technology transfer to commercial partners (i.e., Roy F. Weston)
4. Final technical wrap-up covering the entire project period

SUBJECT TERMS

Biomonitoring, real-time monitoring, hazard assessment, automated monitoring, acute toxicity, chronic toxicity, honey bee colony populations, environmental exposures, exposure characterization, effects characterization, air quality, terrestrial environment, chlorinated hydrocarbons, BTEX, heavy metals, military unique chemicals, statistical approaches.

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SECTION 1 OVERVIEW

1.1 PREVIOUS INVESTIGATIONS

Previous investigations conducted at Aberdeen were covered in the annual reports for 1996 through 1999 (Bromenshenk *et. al.*, March, 1997; March, 1998; February, 1999; and January, 2001). A summary of these activities follows:

- In 1995, a pilot test and demonstration of the honey bee biomonitoring technology was conducted by deploying six electronic hives for two weeks in August at West Branch Canal Creek. The trial concluded that bees could be maintained at this location and that trace amounts of volatile (VOCs) and semi-volatile (SVOCs) could be found inside the colonies. No acute toxicity was observed during the test.

- In 1996, electronic hives were deployed in June/July at Old O Field, West Branch Canal Creek, and at a Churchville reference site. Additional survey hives were deployed at Old O Field and several locations across the Canal Creek Study area. The colonies remained on site until late fall. Capping of the landfill at Old O Field was undertaken while the colonies were on-site. The study found that a wide array of VOCs and SVOCs occurred in hive atmospheres and in ambient air at many of the APG Edgewood locations. In general, the levels of VOC and SVOC contaminants were highest at Old O Field. In addition, the queens from half of the hives at Old O Field disappeared in August. One queen was observed walking about in front of her hive. Normally, mated queens only leave a hive with a swarm of bees as the colony divides to reproduce. A queen leaving a hive by herself is highly unusual. The colonies lacking queens also recorded the highest exposures to bioavailable chemicals, namely organic solvents. Colonies at West Branch Canal Creek, where a removal action had been completed in 1995, performed as well as or better than the colonies at the Churchville reference site and exposures to bioavailable organic chemicals was usually low compared to other sites. Survey colonies at the Youth Center, Beach Point, and Lauderick Creek locations of the Canal Creek Study Area recorded higher levels of several VOCs and SVOCs than did other colonies on the upper post area of APG Edgewood, although the levels of organics at these three sites usually were considerably lower than those at Old O Field.

- In 1997, a full year of biomonitoring was completed at the Old O Field and Canal Creek Study areas. At the end of the growing season, the electronic hives at West Branch Canal Creek were relocated to J Field, where preliminary background data was obtained prior to initiation of an installation restoration removal activity. Twelve additional survey sites were established across the Bush River Study area to characterize that part of APG Edgewood. As in 1996, the highest levels of VOC and SVOCs usually were observed at Old O Field, but the concentrations tended to be lower by an order of magnitude than during the previous year. None of the Old Field colonies lost their queens; nor was any acute toxicity observed in any of the colonies. However, overall colony performance was more variable and colonies were weaker at Old O Field than at either West Branch Canal Creek or the Churchville reference site. The capping of the Old O Field landfill begun in 1996

was completed during the 1997 biomonitoring period. As in 1996, the highest contaminant levels in the Canal Creek area were again observed at sites known to have some exposure to VOCs and SVOCs. The Youth Center again ranked among the three highest sites in terms of exposure concentrations. Prior to the 1996 biomonitoring study, this site had not been reported as exposed to these contaminants. Although the chemical levels were low (parts per trillion in hive atmospheres), this site continued to rank among those known to have exposure sources. As in the previous year, the bees at West Branch Canal Creek did as well as or better than the reference site in terms of overall colony condition and recorded exposures to organic contaminants. Not surprisingly, several of the Bush River sites, which contained several chemical storage facilities and old landfills, also displayed higher than background exposure concentrations to some VOCs and SVOCs .

- In 1998, we continued the biomonitoring at Old O Field and J Field, began a survey of D Field, and initiated a Boundary Site survey using locations near the APG boundary and along transects extending into the communities surrounding the Army Post. Continuing the Old O Field study provided a post-capping evaluation of the effectiveness of the restoration project in terms of reducing bee exposures to VOC and SVOCs and improving colony performance. The J Field study provided ongoing monitoring of the removal project began in the summer of 1998. Again, the J Field bees provided a means of assessing exposures and colony condition during the restoration activities as well as the information needed for a post-removal action assessment. Overall, all of the measured colony performance metrics indicated similar, but slightly degraded, behaviors for 1998 compared to 1997. The only losses of bees occurred at three of the off-post Boundary sites and at Carroll island - the cause remains unknown. As in previous years, the same general types of volatile and semi-volatile organic chemicals were seen at APG sites. Taking all of the VOC and SVOC contaminants into consideration, in general the levels of exposure to organic chemicals at APG sites was not better nor worse than those seen regionally off-post.

- In 1999, we resumed the biomonitoring at J Field, began monitoring Cluster 3 prior to the initiation of cleanup activities, and conducted a verification of the Boundary Survey. Calibration trials at the Churchville reference site confirmed results from our MT reference sites that indicated that the real-time monitoring system could readily detect behavioral changes due to exposure to an acutely toxic chemical. Although changes in flight activity are not chemical specific, these studies show that the real-time system is capable of detecting bee mortality. The J Field study provided ongoing monitoring of the removal activities at the site and added investigations of VOCs in the air and of possible transport of these chemicals into beehives that were placed around the J Field phytoremediation grove. Colonies at J Field displayed higher variability in overall flight activity and performance than in the previous year or at either of the other two monitored sites.

- For all years, slightly elevated levels of a few trace elements and heavy metals were observed at some APG sites, although the levels of bioavailable inorganic chemicals were low compared to those observed in bees from industrial regions near copper and lead smelters. Statistically, strontium was elevated at J Field and somewhat

elevated at Cluster 3. Manganese displayed an exposure gradient, with sites near Chesapeake Bay (both on- and off- post) typically showing higher concentrations than sites farther in land.

- In 2000, we continued the biomonitoring at J-Field and Cluster 3 and moved to Churchville reference hives to Worten Point on the Eastern Shore of Chesapeake Bay. This work was conducted under a new contract with Roy F. Weston and is the first step in the transition of the honey bee biomonitoring technology into commercial applications.

1.2 DATA INFORMATION GAPS

In reviewing APG documents for data that be used to evaluate the degree of correlation between standard methods of sampling soil and water for contaminants and site characterization based honey bee monitoring for purposes of risk assessment, problems were encountered in accessing the original data. In order to make the data collected during the present six-year study more useable, we created an electronic data base of APG chemical exposure data, which includes a capability of cross-referencing and plotting results for specific sites, dates, and locations using a geographic information system. Example printouts of the data base structure and output are included elsewhere in this report (Section3, Unit 3.9 Database Output) showing concentrations of certain chemicals by sample type, date, and locations.

We also found that many of the contract laboratories who provided previous APG chemical analysis results and the associated quality assurance/quality control information, did not provide digital reports. Getting the data in digital format, if available at all, would have entailed an additional cost.
Most laboratories could not provide a digital version of the data set after the work was done, despite the fact that all of the data was originally output in a digital output form from their instruments.

Reviewing our own reports, we found that we also had summarized the data in a manner that would make it difficult for someone else to examine the data for specific dates and locations. Although we always provided a copy of the data in a digital format, it was provided for each year in a generic data format. That precluded anyone from readily conducting any form of comprehensive multi-year, multi-location, multi-date comparison for all of the various sample matrices. For these reasons, we constructed a digital database as a major component of this final report.

1.3 LIMITATIONS OF PAPER REPORTING FORMATS

Whereas we recognize that decision makers need reports that summarize studies and that provide conclusions and recommendations, we also realize that they should have easy access to the original information. Some of the difficulties with working with paper copies of summary reports include:

- Information cannot be easily searched, sorted, queried, or compared, neither within the data set, nor with other studies, if it is not provided in digital form,

- Data cannot be examined for individual samples, matrices, dates, and locations based on data summaries.

- Detection of a chemical exposure or population response may simply reflect what was measured by any individual investigator group.

- Retrospective data analysis or additional information cannot be generated without access to the original data set.

1.4 EXAMPLES OF INFORMATION GAPS/DIFFICULTIES CREATED BY PAPER REPORTS

We were able to extract from APG reports, analysis results for metals, radionuclides, and pesticides in soils, sediments, water, animals, and vegetation. Similarly, we obtained air quality data from the Maryland Department of the Environment. These reports covered measured concentrations of volatile organic chemicals at several sites from the period of 1996-1999. In all cases, the data was only available as a paper copy. We had to manually transfer the data to a digital format.

We reported detectable levels of chemicals, such as strontium, that had not been reported by other investigators. However, based on their written reports, we could not determine whether they had been unable to detect strontium, or whether they had not analyzed for this chemical. We suspect the latter.

We found numerous reports that listed a chemical of concern as being present or absent in some proportion of the total samples (e.g,, PCBs found in 17 of 20 samples), with little or no data on the concentrations found in any specific sample.

Finally, we received requests from APG Installation Restoration Project Officers for access to the results that we had obtained in a form that a Project Officer could use to compare her/his site(s) with other APG sites.

It is impossible to predict what uses decision makers will require of data — whether it will be used to survey sites, characterize sites, assess compliance with regulations, evaluate success of restoration activities, provide information for use in an ecological or human health risk assessment, or assessed for some other purpose. In many cases, the guidelines for use, such as how to conduct a risk assessment continue to change and evolve.

1.5 INFORMATION TECHNOLOGY TOOLS PROVIDED BY THIS REPORT

This final technical report provides a comprehensive database of the chemical exposure data in a form (Access© data base) that can be used in conjunction with the colony behavioral response data (also in digital format), and a means of cross-referencing and plotting results for specific sites, dates, and locations using a geographical information system (ArcView®).

Our emphasis on chemical exposures in the final database is based on the concept that traditional site characterizations and risk assessments are based on chemical concentrations. These data are familiar to decision makers. Although interpretation of chemical concentrations in bees, pollen, or the atmospheres inside beehives requires some "expert" knowledge of honey bee systems, chemical concentrations in ambient air should be relatively easy to interpret by anyone knowledgeable about EPA and other regulatory guidelines.

Previously, we provided tools such as custom numerical processing software (SiteView©) (King, 1998) and Artificial Neural Networks (ANNs) (Seccomb, 1998) for the interpretation of the bee behavioral response data. To successfully use these tools requires specialized training, software, and computers with fast processors and extensive storage capabilities. Even with these tools, final interpretation of results still requires the input of a bee specialist. In addition, there are no regulatory guidelines for processing this type of information.

A simpler approach, similar to a quality control chart that keeps a running tally, was needed. Our objective was to identify a method that would use conventional statistical approaches, could be run in real-time, and could easily be performed on most note book or desk top PC computers. This final report recommends a statistical approach for processing honey bee flight activity that can be conducted in real-time or near real-time, can be performed on most desktop and notebook PC computers, and uses familiar and conventional statistical methods.

Finally, much of the research and development conducted to evaluate and calibrate the real-time, electronic hive system for detecting honey bee colony responses to exposures to toxic chemicals was performed by M.A. Taylor as part of her Master's Thesis (2000). That report has been included as a Technical Appendix.

SECTION 2 STATISTICAL EVALUATION OF HONEY BEE FLIGHT DATA

2.1 FLIGHT ACTIVITY VERSUS FORAGER MORTALITY

The advantage of using bees as environmental monitoring systems goes beyond their efficiency as wide area collectors of contaminants. Because they are living systems, they tend to respond dynamically to changing environmental conditions, especially acute exposure to harmful conditions. Increased mortality is an obvious response to particularly lethal exposures. Acute exposures to toxic chemicals result in readily detectable reductions in the number of bees returning to the hive and can be detected by our hive-mounted counters.

But, it is important to understand that more subtle responses occur as a hive adapts to maintain homeostasis. Behavioral responses in particular occur rapidly. Departures from normal behavior patterns, if detectable, can provide a quick, although generalized, indication of possible exposure to a wide array of environmental hazards. When we began this six-year study, we anticipated that an especially useful and easily measured behavioral component of colonies would be flight activity.

The counters attached at the entrance of the hives deployed during this study provided accurate and continuous measurements of numbers of bees leaving and returning to each hive during the daily foraging period. During the first years of this study, numerical processing software was developed to extensively examine specific patterns of bee flight (King, 1998). Although this is a very sensitive method for examine any given colony, set or colonies, or comparing the activities of colonies at one location with those of another, it is labor intensive. We also used Artificial Neural Networks (ANN) to process the data. ANN proved to be particularly useful for flagging behavioral anomalies (Seccomb, 1998), but application of this method requires a specialist trained in the programming and use of ensembles of ANNs. As such, we took a final look at the data in order to see whether a simpler statistical method could be used to process the data. We used data from a selected sample of hives to evaluate whether changes in environmental conditions could be seen and statistically identified in flight activity patterns.

Our objectives were to:

- **Determine how best to summarize daily flight activity**. Bee flight activity is dynamic. Continuous records produce especially noisy data. Effective monitoring and analysis required an approach to smoothing and summary that reduced noise but preserved real variation in flight profiles through time.

- **Assess whether patterns of flight activity were generalizable among different colonies under normal conditions**. If each hive is idiosyncratic in the profile of outgoing and incoming flights during the day, standardization is not possible. In that case, in routine monitoring and sampling, each hive would have to be benchmarked before deployment, making use of flight behavior unproductive except in exceptional cases. On the other hand if a generalized profile exists, or if simple transformations can produce concordance, then normal flight activity can be predicted and significant departures from normal would signal an event requiring further investigation.

- **Compare transformed profiles of normal colonies to profiles under known environmental perturbations.** Final verification of the utility of bee behavior as an indicator of acute environmental events depends on the ability to detect changes in flight profiles in response to known perturbations. If a QA/QC approach is feasible then automated or semi-automated systems can be developed to monitor colonies efficiently.

We must state at the outset that flight activity analysis was not the principal objective of this study. Flight activity data were collected to test the feasibility of this use of behavioral data. Consequently we did not perform a full analysis of all colonies, sites, and years, but instead conducted the preliminary analyses presented here.

2.2 SUMMARIZING DAILY FLIGHT ACTIVITY

We began by arbitrarily selecting what we judged to be a typical flight profile for one of the colonies. We chose a data set from the Eastern Shore cluster of colonies (ES000702, Figure 2.2.1). This data set illustrates the usual pattern of numbers of bees leaving a hive over a 14 hour active period on July 7, 2000.

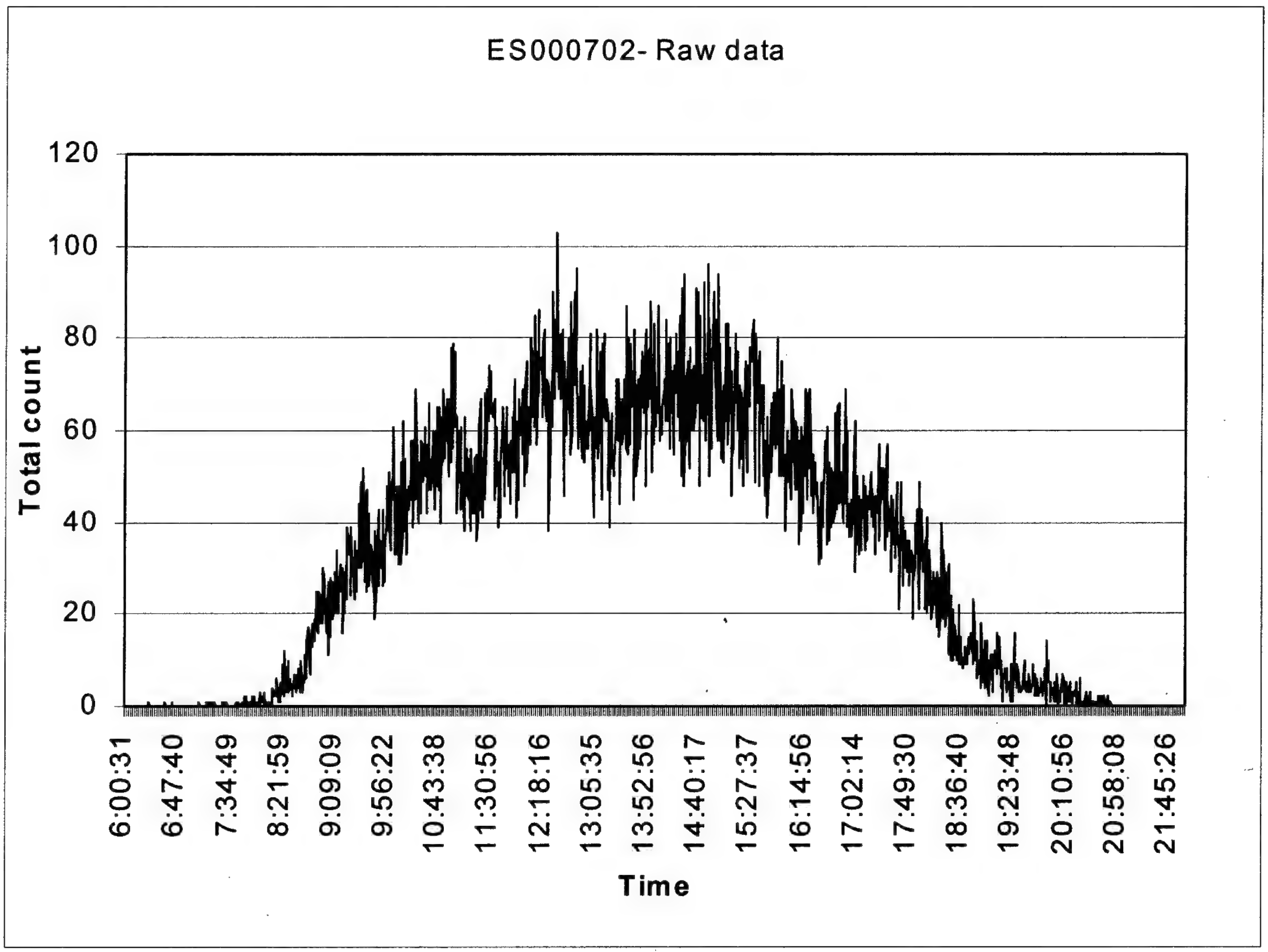


Figure 2.2.1 Flight activity pattern, total counts, single colony.

Flight activity begins one to two hours after first light and increases only slightly until ambient temperatures and light intensity reach an optimal threshold. Flight activity then increases rapidly to a maximum during midday, then declines nearly symmetrically. Note that although the mean flux is 62 bees per measured time interval, there is 20 percent variation about the mean..

We found that double smoothing the raw data over a 5 minute interval produced the best compromise of noise reduction with retention of major peaks and declines in activity (Figure 2.2.2). Fitting the log transformed, doubly smoothed, 5 minute data to a predicted quadratic curve resulted in an excellent fit (Table 2.2.1; $R^2 = 0.95, P < 0.0001$). Ninety-five percent confidence intervals about the predicted line included all variation in the smoothed data except the pre-threshold period before 0900 hours in the sample data set (Figure 2.2.3).

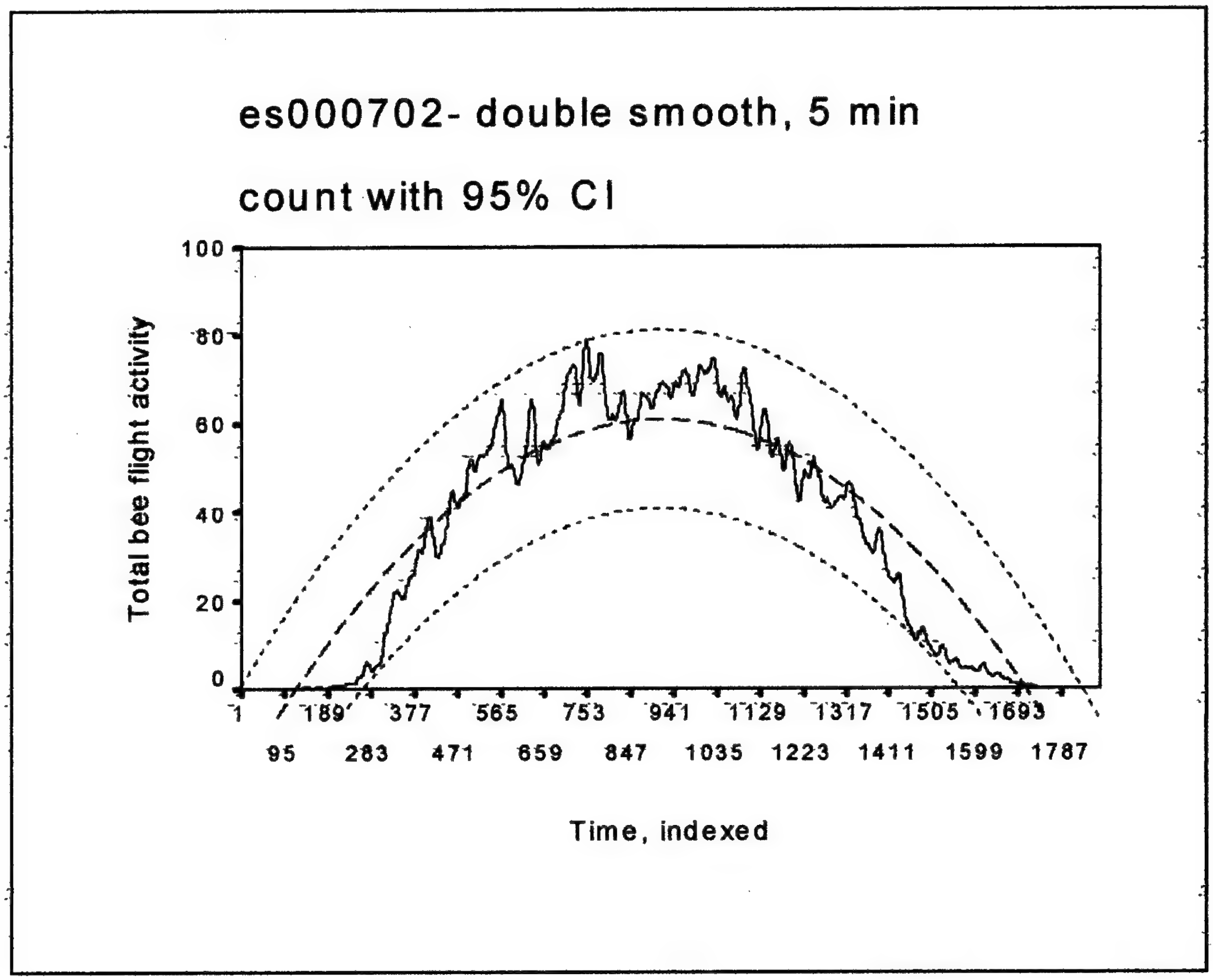


Figure 2.2.2 Flight activity, double smoothed, 5 minute intervals.

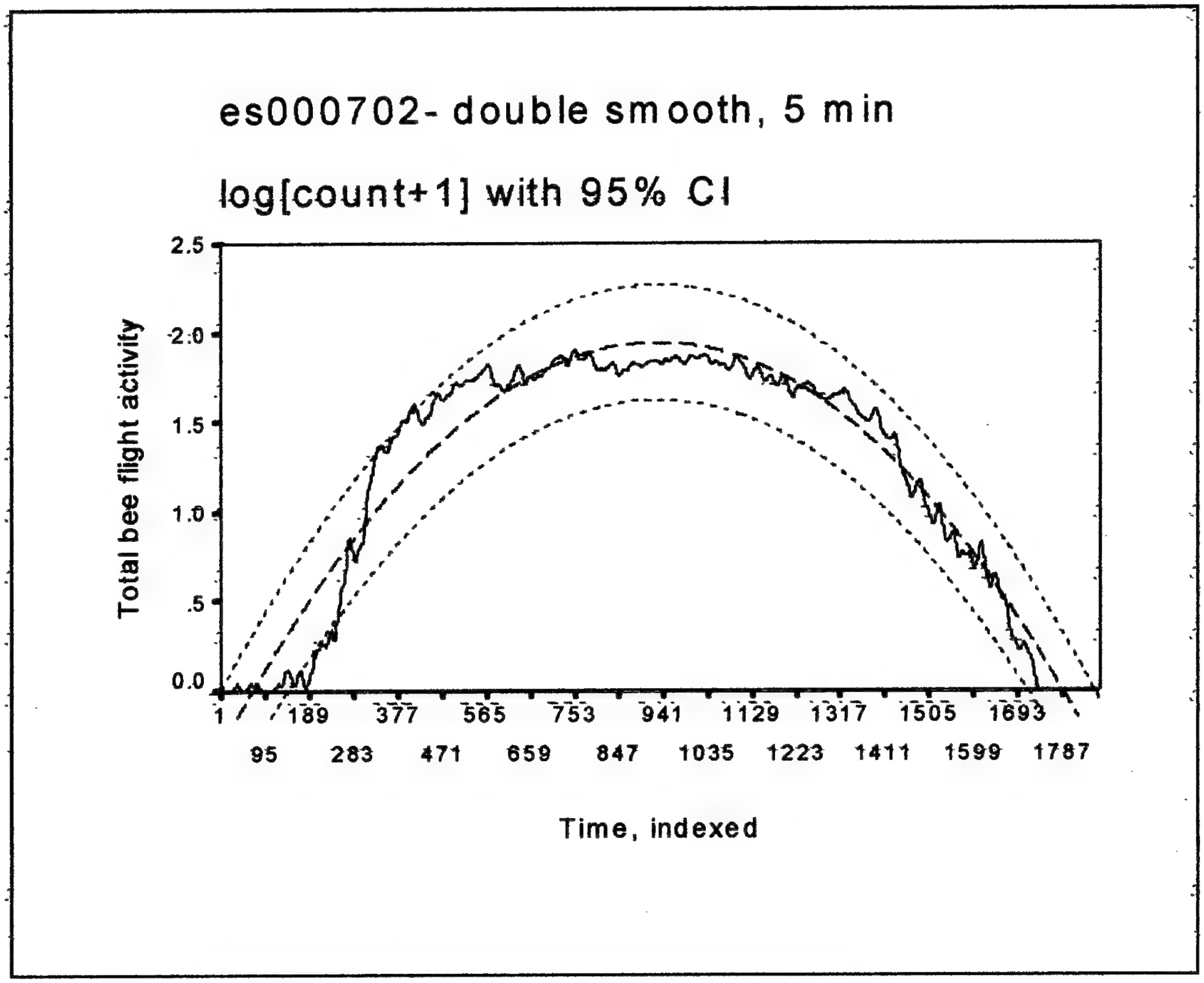


Figure 2.2.3 Flight activity, 5 minute intervals, log transformed, double smoothed, fitted to predicted quadratic curve.

Table 2.2.1

**Fit of the Log Transformed, Double Smoothed,
Bee Counts at 5 Minute Intervals
to a Predicted Quadratic Curve**

Independent: TIME

Dependent	Method	R^2	d.f.	F	Sigf	b0	b1	b2
Log [count+1]	Quadratic	0.946	186 6	16278.1	0	-0.323	0	-3e-06

The following new variables were created:

Name	Label
FIT_2	Fit for LOGC with TIME from CURVEFIT, MOD17_Quadratic
ERR_2	Error of LOGC with TIME from CURVEFIT, MOD17_Quadratic
LCL_2	95% LCL for LOGC with TIME from CURVEFIT, MOD17_Quadratic
LCL_2	95% UCL for LOGC with TIME from CURVEFIT, MOD17_Quadratic

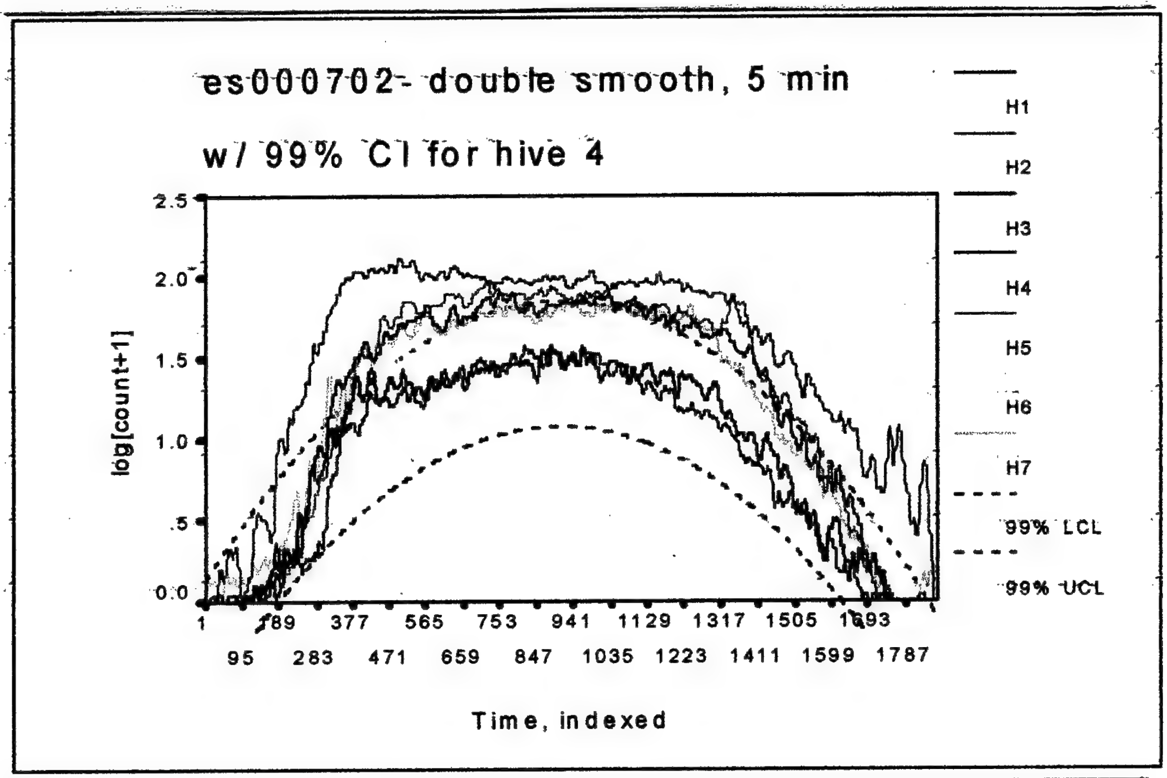
2.3 GENERALIZABILITY AMONG COLONIES

Having settled on double smoothing followed by log transformation to reduce data noise, we next selected a subsample of flight profiles for an additional six colonies from the Eastern Shore complex to assess generality of flight activity. We observed considerable variation among the colonies, even though the sampled data came from the same site and the same general time period (Figure 2.3.1). Although all colonies showed the same general activity pattern, the levels of activity varied more than two-fold between the lowest and highest counts.

We corrected for the variation by scaling each hive to the highest mean maximum count measured over the entire flight period. Each hive was then scaled by addition of the difference between its maximum count and the mean maximum to each measurement. The result showed remarkable convergence of all flight profiles (Figure 2.3.2). The only excessive variation that remained appeared near the increase inflection point and on the decreasing slope for one hive, number two.

Simple additive scaling based on the mean maximum count is an easily applied and readily automated algorithm. It suggests that the chief difference between colonies within a site was just the number of bees flying at any given time–the rate of change is consistent but at different levels of activity at any given moment. We tested this conclusion further by comparing the Eastern Shore profile parameters to colony data from Fort Missoula in Montana.

When scaled to the mean maximum count from Eastern Shore, the Fort Missoula colonies matched the early increasing, peak, and late decreasing phases of the flight profile (Figure 2.3.3). They deviated substantially, however, near the inflection points for both increasing and decreasing phases. The rate of increase at the start of flight activity and at the end of activity were much steeper in Montana. Our previous investigations have clearly shown that there are regional differences in the initiation and ending of colony flight activity that relate to day length cycles. Nonetheless, the ability to match flight profiles for colonies from Maryland and colonies from Montana shows an encouraging convergence even across these large distances.



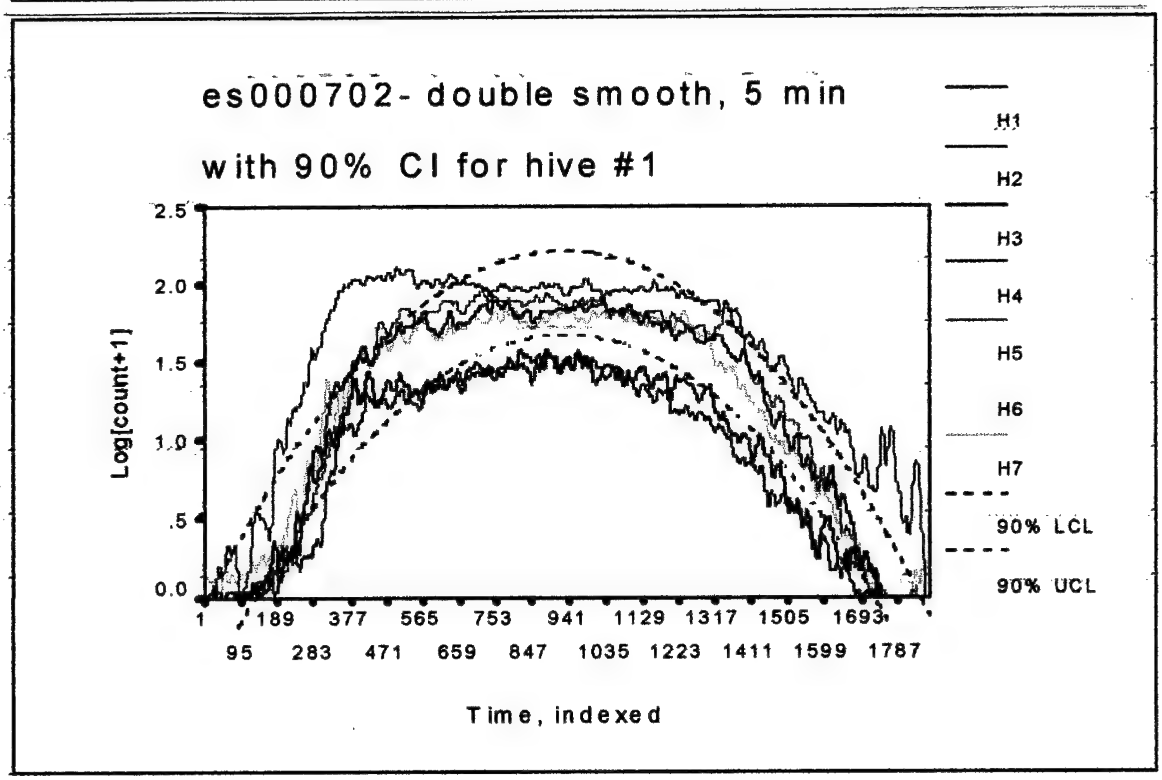
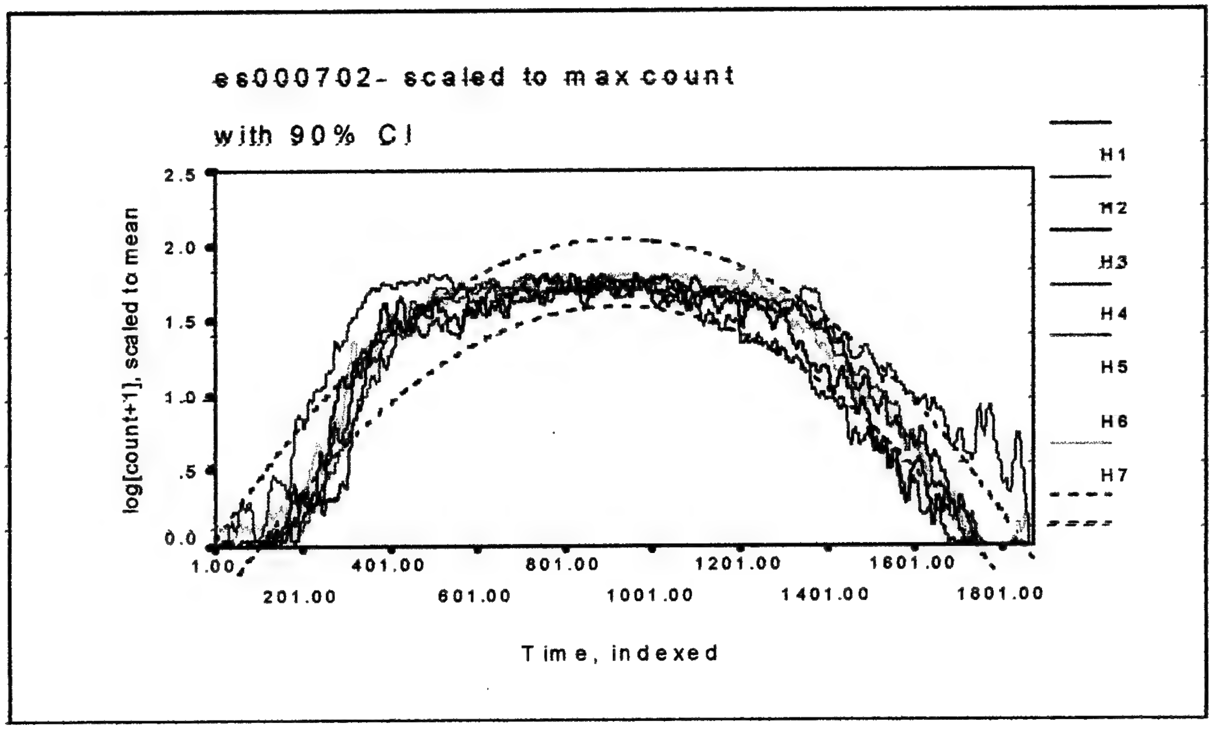


Figure 2.3.1 Eastern Shore colony comparison, double smoothed.



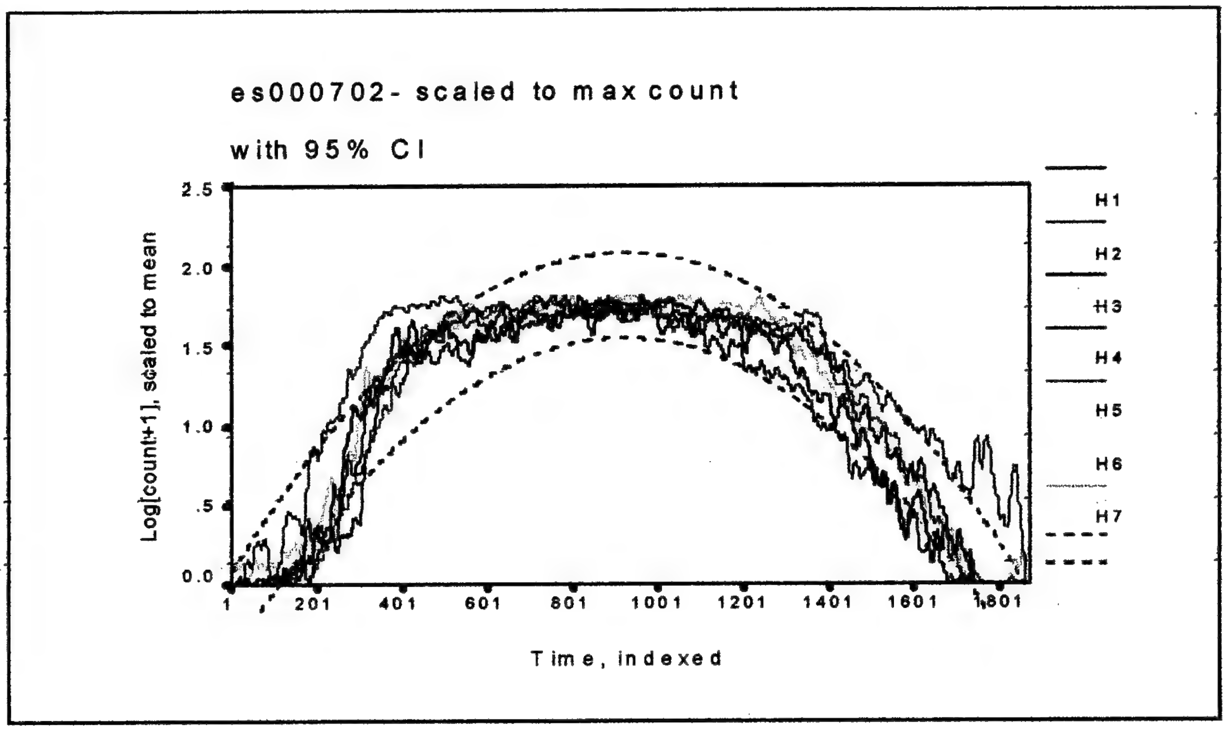
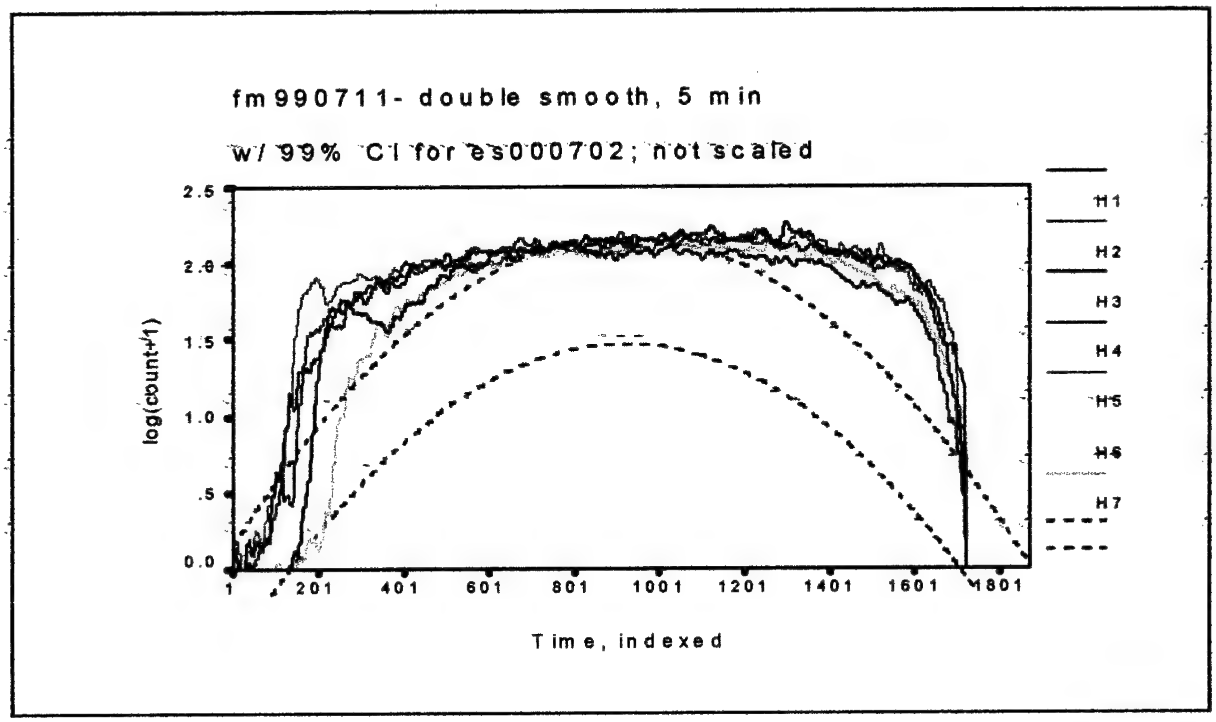


Figure 2.3.2 Eastern Shore colony comparison, scaled to maximum count.



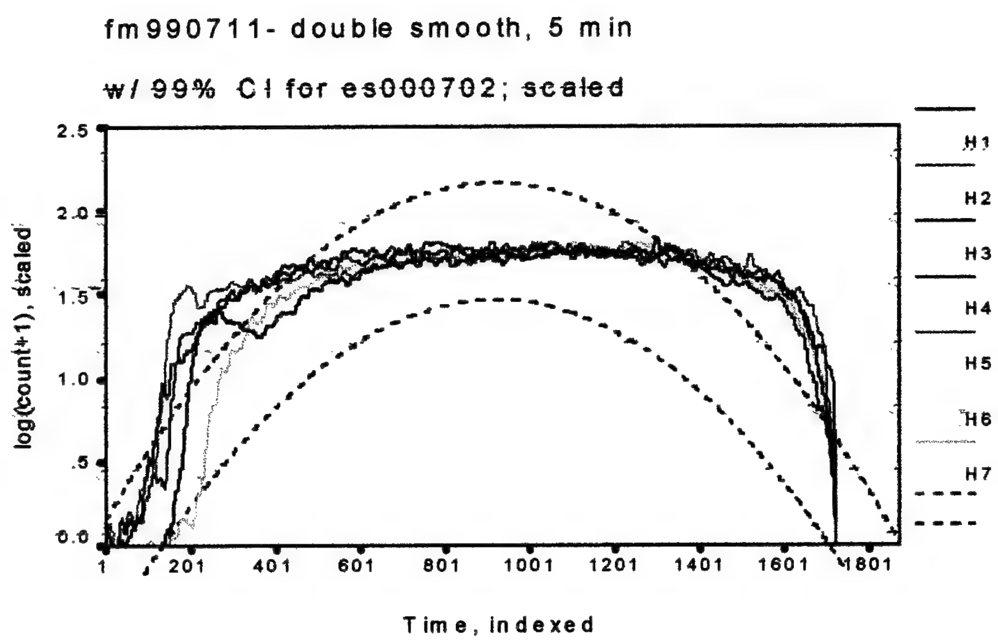


Figure 2.3.3 Fort Missoula, MT colonies scaled to Eastern Shore, MD colonies.

2.4 RESPONSES TO ENVIRONMENTAL PERTURBATIONS

Figure 2.4.1 illustrates the flight patterns for two sets of six Eastern Shore colonies with respect to thunderstorm disruptions of flight activity. We used these flight patterns because we had confirmed perturbations at known times. The profiles clearly indicate storm occurrences at midday that depressed flight activity below the 95 percent confidence limits predicted from the normal set.

All but two colonies began the day with a normal increase in flight activity and recovered to normal flight parameters following the storm disturbance. The two non-conforming colonies differed in that they delayed initial activity and declined more sharply at the end of the day. Nevertheless they responded similarly to the other colonies when the disturbance occurred. The cause for the difference is not clear, but may be due to hive colony genetics or condition. In previous years, we found that a small proportion of colonies respond differently to storm disturbance than the majority of the colonies, especially with respect to how soon they resume normal flight activity. We also noted differences between weak and strong colonies in terms of when they again begin foraging. Under behavioral monitoring applications, such delays and early cessation would be important indicators that a hive is losing reliability or is an outlier, triggering closer inspection to determine the cause and possible substitution to normalize the set of test colonies. Presumably, colonies could be pre-screened for this trait (if genetic).

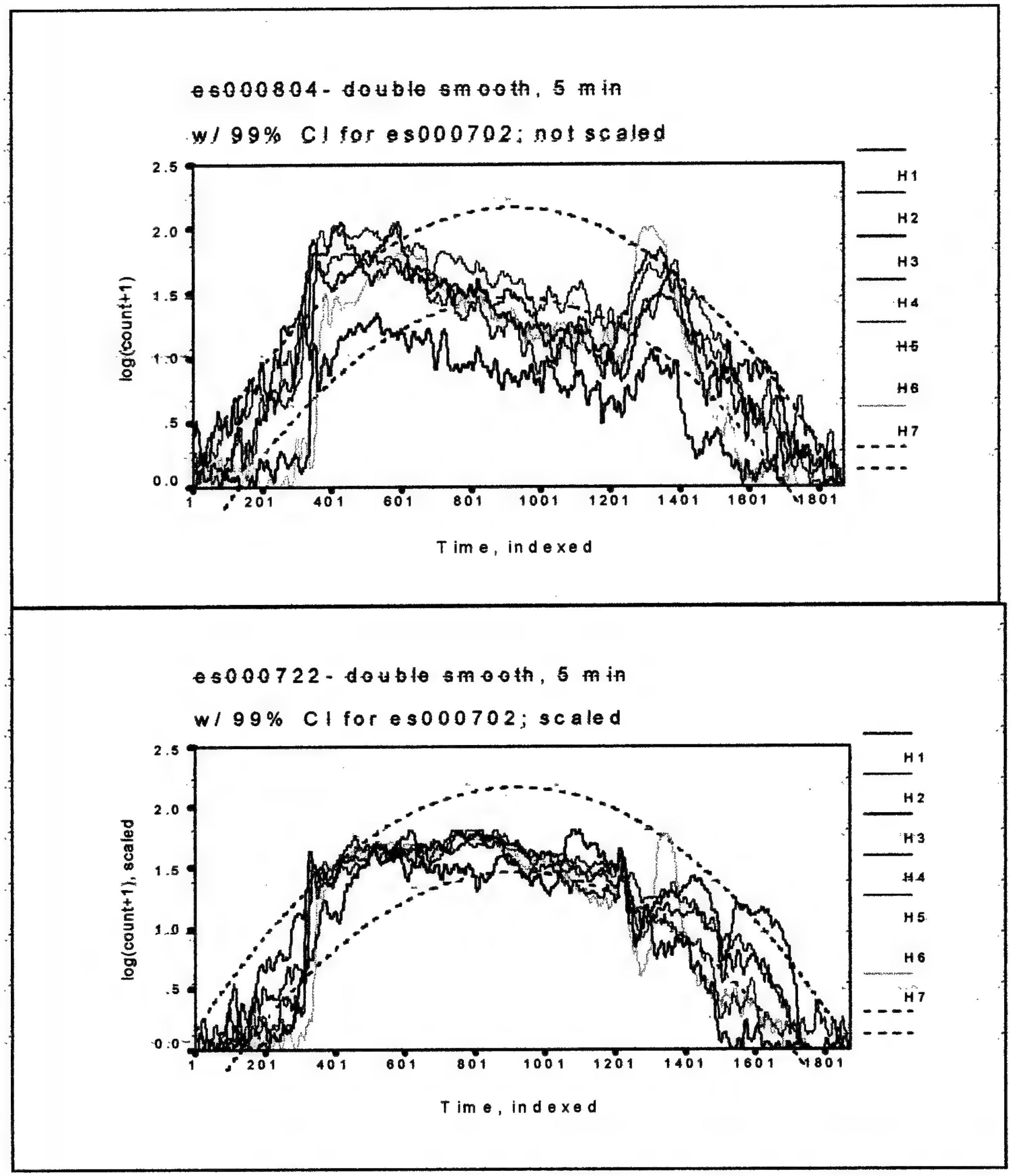


Figure 2.4.1 Depression by a thunderstorm of flight activity below the 95 percent confidence limits predicted from the normalized data set.

2.5 CONCLUSIONS

Although these are illustrative data, they suggest to us that relatively simple statistical procedures can be employed to render flight activity data a more useful tool to monitor for acute perturbations at sensitive sites. The resultant method can be used like a running control chart with upper and lower control limits. The rapid response of bees and its ease of detection when coupled with the overall sampling efficiency we have demonstrated, makes the use of active bee colonies a promising tool for environmental monitoring and research.

SECTION 3 CHEMICAL EXPOSURE DATABASE

3.1 INTRODUCTION

A six-year summary of the chemical analysis results for the APG bee biomonitoring work was compiled into Microsoft Excel© spreadsheets and ported to a Microsoft Access© database. This enables authorized users to sort and rearrange data on a basis of any perimeter. For example, a user can sort the data by location and that will automatically group all measurements from a single site into contiguous blocks. Sorting of subsets provide capabilities such as seasonal comparisons, arrangements of highest to lowest observed concentrations or single colony comparisons. The nine Tables that appear in this report are provided for the use of readers who do not have access to the database or those who wish to look up specific chemicals in a hard copy format.

3.2 DATA COMPONENTS

The database is a compilation of Microsoft Excel spreadsheets containing sample identification information, sample matrix, date sampled, location sampled, and chemical concentration amounts. These are divided into four general categories. An inventory of the database appears in Appendix A of this report. Table 1 of the Appendix lists the sample sites sorted by year (1996-2000). Table 2 lists the volatile organic compounds and Table 3 lists the trace elements and heavy metals sorted by year (1996-1999). Table 4 lists the radionuclides and pesticides analyzed for 1998 and 1999.

Table 5 lists the dates and file numbers of the volatile organics samples sorted by year and location. Table 6 provides the same information for trace elements and heavy metals, Table 7 for the radionuclides, and Table 8 for the persistent pesticides and PCBs.

3.3 Data Fields

The following is a brief explanation of the fields within each of these respective tables.

- Volatile Organics Compounds Data for Ambient Air and the Air Inside Beehives
- Trace Elements/ Heavy Metals Data for Bees and Pollen
- Radionuclides Data for Bees and Pollen
- Pesticides Data for Bees and Pollen

3.4 Volatile Organic Compounds Data

In the Volatile Organic Compounds Data table, the sample identifiers include:

- **File #** - designates a sequential GC/ MS folder and file reference number for each sample.

- **Site ID**- designates samples combining geographic location, position and supplemental data for the purpose of internal control.

- **Location** - designates the actual geographic location sampled.

- **Position** - designates spatial arrangement of hives within a geographic area or specific location.

- **Type of Sample** - designates whether the sample came from the air inside a Condo (electronic), Survey or Phytoremediation (A, B, C, D, or E) hive, or if the sample came from the ambient air in that area.

- **Hive #** - designates the number labeled on the outside of each hive that distinguishes one hive from another.

- **Sample #** - designates a code used by experimenters for internal control.

- **Date Taken; Year / Month / Day** provides dates in two formats. One combines the date into one field. The first four digits represent the year, the next two digits represent the month, and the final two digits represent the day. This field accommodates sorting more efficiently. The alternative format shows the date separated into three fields for overall viewing ease.

Unless otherwise noted, all chemical concentrations for volatile organic compounds are expressed in parts per trillion by volume and nanograms per cubic meter. Please refer to table #2 in Appendix for list of all volatile organic chemicals.

In 1999, we installed new GC/MS/TD instrumentation, new analysis library software, went to an expanded calibration standard, and reported values in concentration units. Prior to 1999, we used an older instrumentation system and libraries, an internal standard, and reported values in terms of relative ion abundance. We have back-computed the concentrations for the 1996-1998 samples, but the accuracy of these results is more variable than for 1999 and 2000.

3.5 Trace Elements/ Heavy Metals Data

In the Trace Elements/ Heavy Metals table the sample identifiers include:

- **Sample ID** - a single number that designates each sample for the purpose of internal control.

- **Location** - designates the actual geographic location sampled.

- **Position** - designates spatial arrangement of hives within a geographic area or specific site.

- **Hive ID** - designates the number labeled on the outside of each hive that distinguishes one hive from another.

- **Bee #** - designates the number labeled on the inside of each hive that corresponds with a particular colony of bees. (For example, if a group of bees died in the middle of a season, a new colony would be placed in the hive and the number would be updated.)

- **Type of Sample** - designates whether the sample was of Live Forager Bees, Dead Bees, or Pollen.

- **Date Taken; Year / Month / Day** - provides dates in two formats. One combines the dates into one field. The first four digits represent the year, the next two digits represent the month, and the final two digits represent the day. This field accommodates sorting more efficiently. The alternative format shows the date separated into three fields for overall viewing ease.

- **Supplemental Data** - compiles information for internal experimental information and designates any duplicate samples.

After the identifiers, the nineteen trace elements/ heavy metals are listed in separate fields and are followed by measurements of Mass, Count /ISR, Concentration in ppm, Standard Deviation, and RSD %. Please refer to Table 3 in Appendix A for a list of trace elements and heavy metals.

3.6 PESTICIDE DATA

In the Pesticides Data table, the sample identifiers include:

- **Sample ID -** a single number that designates each sample for the purposes of internal control.

- **Location** - designates the actual geographic location from which each sample was obtained.

- **Type of Sample** - designates whether the sample was of bees or pollen.

- **Date -** designates the date that the sample analysis was completed.

After the identifiers, the twenty-eight pesticides and derivatives are listed in separate fields and are followed by the concentration measurement units of ug/kg. Because analysis for a broad spectrum of pesticides requires very a large sample of biological tissue, bee and pollen samples were pooled by type across each season (year) of sampling. Therefore, sample collection date is given as to the year taken, not the actual day. Please refer to Table 4 in Appendix A for a list of the pesticides assayed.

3.7 Radionuclide Data

In the Radionuclide Data table, the sample identifiers include:

- **Sample ID -** a single number that designates each sample for the purpose of internal control.

- **Location** - designates the actual geographic location sampled.

- **Type of Sample -** designates whether the sample was of bees or pollen.

- **Date** - designates the date that the sample analysis was completed.

After the identifiers, the four detected radionuclide species are listed in separate fields followed by a qualifier field, and then the concentration measurement units of pCi/g. As with the analysis for pesticides, detection of radionuclides at low concentration in biological tissues requires a large amount of biological tissues. Bee and pollen samples were pooled by type across each season (year) of sampling, with the majority of the samples taken in August/September. Therefore, sample collection date is given as to the year taken, not the actual day. Please refer to Table # 4 in Appendix A for list of radionuclides surveyed.

3.8 HOW TO USE DATABASE

We developed the data set in Microsoft Excel© spreadsheets, which we then ported to Microsoft Access© database. This final technical report includes a copy of the Bee Monitoring Chemical Data on disk. Having the chemical exposure and fate information in this database format pulls all of the information together into a single file, provides search and sort capabilities, and can link multiple tables through queries and reports. For first time users, we provide the following guidelines:

Open database:

Open database by selecting the Zip drive and double click on "Bee Database".

Searching Access:

Click "Table" tab to open a table then double click on table of interest. To find specific data, click "Edit", scroll down to "Find" and enter the value or terms of interest. An item of interest may be part of a cell or an entire cell.

Sorting:

The sort option is a great advantage. To sort first click on the "Table" tab to open the table menu, then double click on table of interest. Next, click on the top of any specific column and sort that field in either descending or ascending order by clicking the Z to A or the A to Z buttons at the top of the screen respectively. This will sort either numeric or text entries.

Advanced Sorting:

Although this procedure takes longer, it is very valuable for making tables that include only certain values. An advanced sort can be performed from the "Records" menu. Click "Records", scroll to "Filter", and finally "Advanced Filter / Sort". Simply, drag the columns of interest into the columns below in order of importance. After the fields are entered into the columns, select (in the Sort: row) either "descending", "ascending", or select "not sort". The columns will be sorted in order of importance from left to right.

Queries:

Queries are a type of advanced sort and search. To make a query, click the "Query" tab then click "New"; next click "Design View". Choose from the list of tables and add the table(s) of interest by double clicking on the table name, then click close. Now follow the same procedures outlined above in Advanced Sorting. Also, in the criteria row you may limit your search to only show results that contain text in that criteria row. Save the query by closing the design view (click on the X in upper right corner). When you try to close, Access will ask you to name the query. Now in the query menu, double click the query name, and the query will open what is called a "dynaset" (a table consisting of only the values deignated in the criteria row and all the other fields listed in the query sheet).

Example Queries:

We have provided queries to search:

- Volatile Organic Compounds Data sorted by location.
- Volatile Organic Compounds Data sorted by date.
- Trace Elements / Heavy Metals Data sorted by location.
- Trace Elements / Heavy Metals Data sorted by date.
- Maximum Values Queries, listed in alphabetical order by compound name.

Running Example Queries:

Click the "Query" tab. Then double click on the query of interest. The computer will ask for either site or first date. Enter the value of interest then click "OK". If performing a date range search, a second box will appear asking for the last date. Enter the value of interest then click "OK". The computer will generate all the values of interest in a "dynaset". Note: You must enter the whole site name for a site search, and you must enter the date in yyyymmdd form.

3.9 DATABASE OUTPUT

Appendix A is intended to serve as an inventory to facilitate determining what matrices, sites, and dates were sampled and for which chemicals. The following Tables were generated using this database and provide a summary of the maximum chemical concentrations observed by sample type, date, and location. It is apparent that for the volatile organic compounds the Tables show a preponderance of samples with maximum values in the 1999 and 2000 data sets. This reflects: 1) Greater sensitivity and detection capability due to improved instrumentation, software, and 2) Calibration for a wider array of compounds. In general, our organics methods evolved and improved from 1995 through 1998. Included was implementation of a multi-bed field sampling system that was first used in 1998 to capture terpenes and remove excess moisture. This increased the number of usable samples, reduced interferences caused by large amounts of terpenes on the sorbent collection tubes, and reduced wear and tear on the GC/MS instrument.

Technically, the 1996 and 1997 samples were collected and analyzed using the same procedures, the 1998 samples were collected using an improved sampling system and the same analysis methods and instrumentation, and the 1999 and 2000 samples were taken using the upgrade sample collection and system. Overall, 1996-1998 samples can be compared among years and sites, and the 1999-2000 samples can be compared. Some caution is warranted when comparing pre-1999 results with 1999 and 2000 results.

In all of the following Tables, a -99 is used to designate a value below detection levels.

Tables Generated from queries:

- **Table 8.9.1** Ten highest concentrations for Volatile Organic Compounds in Ambient Air.
- **Table 8.9.2** Ten Highest Concentrations For Volatile Organic Compounds in Hive Air.
- **Table 8.9.3** Ten Highest Concentrations For Trace Elements/ Heavy Metals in Forager Bees.
- **Table 8.9.4** Ten Highest Concentrations For Trace Elements/ Heavy Metals in Dead Bees.
- **Table 8.9.5** Ten Highest Concentrations For Trace Elements/ Heavy Metals in Pollen.
- **Table 8.9.6** Three Highest Sample Concentrations For Pesticides in Bees.
- **Table 8.9.7** Three Highest Sample Concentrations For Pesticides in Pollen.
- **Table 8.9.8** Ten Highest Sample Concentrations For Radionuclides in Bees.
- **Table 8.9.9** Ten Highest Sample Concentrations For Radionuclides in Pollen.

TABLE 8.9.1 Ten Highest Concentrations for Volatile Organics in Ambient Air
(ranked from highest to lowest, 1-10, Respectively)

	Rank	Conc (ng/m3)	Location	Sample	Year	Month	Day
1,1-Dichloroethene	1	216.6	Cluster 3	Estuary Ambient	2000	AUG	3
	2	185.9	J-Field	40205	2000	JUN	1
	3	106.3	J-Field	40305	2000	JUN	1
	4	101.0	J-Field	20205	2000	JUN	1
	5	92.2	Cluster 13	9921302a	1999	SEP	14
	6	88.1	J-Field	992C205	1999	OCT	16
	7	80.4	J-Field	40105	2000	JUN	1
	8	79.5	J-Field	992AZ05	1999	OCT	16
	9	76.1	J-Field	20305	2000	JUN	1
	10	61.4	J-Field	20102	2000	SEP	28
Dichloromethane	1	371745.5	J-Field	20102	2000	SEP	28
	2	203006.4	Cluster 3	20201	2000	AUG	3
	3	75758.6	J-Field	20501	2000	APR	6
	4	65750.0	J-Field	20402	2000	APR	19
	5	60743.8	J-Field	40303	2000	MAY	3
	6	48595.8	J-Field	20103	2000	OCT	3
	7	46797.8	J-Field	40105	2000	JUN	1
	8	40154.7	J-Field	40203	2000	MAY	3
	9	39740.5	Cluster 3	Estuary Ambient	2000	AUG	3
	10	26651.2	J-Field	40103	2000	MAY	3
trans-1,2-Dichloroethene	1	88.8	J-Field	994T404	1999	APR	28
	2	63.4	J-Field	20203	2000	MAY	3
	3	21.9	J-Field	40206	2000	SEP	13
	4	16.6	J-Field	20102	2000	SEP	28
	5	13.0	J-Field	992A200	1999	MAR	11
	6	10.8	J-Field	40104	2000	MAY	17
	7	6.9	J-Field	992A203	1999	MAR	13
	8	6.5	J-Field	20101	2000	AUG	1
	9	6.3	Cluster 3	20202	2000	SEP	28
	10	4.8	J-Field	20103	2000	OCT	3
1,1-Dichloroethane	1	12.2	J-Field	992B204	1999	APR	27
	2	9.1	Cluster 3	20201	2000	AUG	3
	3	5.6	J-Field	40105	2000	JUN	1
	4	3.7	Jones Farm	992JF02	1999	SEP	14
	5	3.7	Cluster 3	Estuary Ambient	2000	AUG	3
	6	3.5	J-Field	20102	2000	SEP	28
	7	1.9	J-Field	20103	2000	OCT	3
	8	1.7	J-Field	20104	2000	MAY	17
	9	1.5	J-Field	20101	2000	AUG	1
	10	1.2	Conowingo Orchard	992CC01	1999	JUL	27
2,2-Dichloropropane	1	2131.9	J-Field	40303	2000	MAY	3
	2	758.3	J-Field	20402	2000	APR	19
	3	66.9	J-Field	992B204	1999	APR	27
	4	42.2	J-Field	40203	2000	MAY	3
	5	12.9	J-Field	40202	2000	APR	19
	6	7.9	J-Field	40101	2000	APR	6
	7	7.0	J-Field	20302	2000	APR	19

	8	6.4	J-Field	20501	2000	APR	6
	9	6.2	Churchville	992CV02	1999	AUG	3
	10	5.2	J-Field	40103	2000	MAY	3
cis-1,2-Dichloroethene	1	1327.8	J-Field	992T403	1999	APR	13
	2	926.7	Churchville	992CV02	1999	AUG	3
	3	472.0	Churchville	992CV001	1999	JUN	24
	4	323.0	J-Field	40305	2000	JUN	1
	5	254.1	J-Field	20203	2000	MAY	3
	6	218.8	Cluster 3	992CT01	1999	AUG	17
	7	208.0	J-Field	994T404	1999	APR	28
	8	195.2	J-Field	992F201	1999	JUN	28
	9	117.1	J-Field	992B204	1999	APR	27
	10	91.5	J-Field	995T003	1999	APR	13
Trichloromethane	1	1467.5	Jones Farm	992JF02	1999	SEP	14
	2	692.2	Rumsey Mansion	992RI02	1999	SEP	25
	3	453.2	J-Field	992D203	1999	APR	13
	4	433.2	J-Field	40105	2000	JUN	1
	5	418.9	Cluster 13	9921302a	1999	SEP	14
	6	394.9	Churchville	992CV02	1999	AUG	3
	7	382.2	J-Field	992D205	1999	OCT	16
	8	240.6	J-Field	992F201	1999	JUN	28
	9	231.4	J-Field	20405	2000	JUN	1
	10	215.3	J-Field	40205	2000	JUN	1
Bromochloromethane	1	31.3	J-Field	20102	2000	SEP	28
	2	18.4	J-Field	992B204	1999	APR	27
	3	12.0	J-Field	20104	2000	MAY	17
	4	7.4	Cluster 3	20202	2000	SEP	28
	5	5.1	J-Field	20103	2000	OCT	3
	6	1.4	J-Field	992F001	1999	JUN	19
	7	0.0	Jones Farm	992JF02	1999	SEP	14
	8	0.0	Rumsey Mansion	992RI02	1999	SEP	25
	9	0.0	J-Field	992D203	1999	APR	13
	10	0.0	J-Field	40105	2000	JUN	1
1,1,1-Trichloroethane	1	2504.4	J-Field	992AZ05	1999	OCT	16
	2	1736.0	J-Field	992B205	1999	OCT	16
	3	943.0	J-Field	992C205	1999	OCT	16
	4	667.6	J-Field	40202	2000	APR	19
	5	536.7	Jones Farm	992JF02	1999	SEP	14
	6	408.9	J-Field	992D205	1999	OCT	16
	7	374.3	J-Field	40105	2000	JUN	1
	8	367.3	J-Field	992B204	1999	APR	27
	9	348.8	J-Field	992A200	1999	MAR	11
	10	326.1	J-Field	40305	2000	JUN	1
1,1-Dichloropropane	1	631.8	J-Field	20203	2000	MAY	3
	2	409.2	J-Field	40202	2000	APR	19
	3	403.1	J-Field	20103	2000	MAY	3
	4	390.1	J-Field	20303	2000	MAY	3
	5	327.6	J-Field	20305	2000	JUN	1
	6	227.4	J-Field	40204	2000	MAY	17
	7	72.9	J-Field	992B204	1999	APR	27
	8	55.0	J-Field	40302	2000	APR	19
	9	50.9	J-Field	40101	2000	APR	6

	10	38.6	J-Field	20502	2000	APR	19
Tetrachloromethane	1	1168.4	D-Field		1998	AUG	9
	2	977.8	Shawsville		1998	JUL	7
	3	820.4	O-Field		1998	AUG	7
	4	699.6	D-Field		1998	SEP	30
	5	640.6	Cylburn Arboretum		1998	AUG	14
	6	634.0	J-Field		1998	OCT	12
	7	633.9	Jones Farm	992JF02	1999	SEP	14
	8	611.8	Beach Point		1996	AUG	23
	9	611.6	Tower Hill		1998	JUL	7
	10	602.1	D-Field		1998	SEP	30
1,2-Dichloroethane	1	7866.9	Cluster 3	20201	2000	AUG	3
	2	4365.3	Cluster 3	Estuary Ambient	2000	AUG	3
	3	2042.2	J-Field	20102	2000	SEP	28
	4	1760.8	J-Field	40101	2000	APR	6
	5	1394.0	J-Field	40302	2000	APR	19
	6	883.5	J-Field	20303	2000	MAY	3
	7	769.0	J-Field	20203	2000	MAY	3
	8	549.1	J-Field	20103	2000	MAY	3
	9	524.3	J-Field	20305	2000	JUN	1
	10	418.7	J-Field	40204	2000	MAY	17
Benzene	1	9265.7	Cluster 3	Estuary Ambient	2000	AUG	3
	2	5759.0	Cluster 3	20201	2000	AUG	3
	3	5232.1	J-Field	20102	2000	SEP	28
	4	1642.8	Shawsville		1998	JUL	7
	5	1319.0	J-Field	20302	2000	APR	19
	6	1240.2	Shawsville	992SV01	1999	JUL	27
	7	1189.3	Tower Hill	992TH02	1999	SEP	24
	8	1159.0	Lorh's Orchard		1998	JUN	9
	9	1079.7	J-Field	40104	2000	MAY	17
	10	932.8	J-Field	20102	2000	APR	19
Trichloroethene	1	6751.9	J-Field	994T404	1999	APR	28
	2	2213.5	J-Field	40206	2000	SEP	13
	3	1629.2	J-Field	990T403	1999	APR	13
	4	425.5	J-Field		1998	AUG	29
	5	418.1	J-Field	990T400	1999	MAR	11
	6	361.0	Youth Center		1996	AUG	23
	7	298.4	J-Field		1998	OCT	12
	8	297.8	J-Field	40305	2000	JUN	1
	9	296.2	J-Field		1998	AUG	29
	10	274.9	J-Field		1998	AUG	29
1,2-Dichloropropane	1	503.9	J-Field	992B204	1999	APR	27
	2	144.0	J-Field	20103	2000	OCT	3
	3	16.4	J-Field	20506	2000	SEP	13
	4	12.5	Cluster 3	20201	2000	AUG	3
	5	5.4	Jones Farm	992JF02	1999	SEP	14
	6	4.4	J-Field	992T004	1999	APR	28
	7	4.2	J-Field	20102	2000	SEP	28
	8	4.2	J-Field	992D203	1999	APR	13
	9	2.8	J-Field	99TT000	1999	MAR	11
	10	2.3	J-Field	994T004	1999	APR	28
Bromodichloromethane	1	67.0	Cluster 3	20201	2000	AUG	3

	2	51.2	Jones Farm	992JF02	1999	SEP	14
	3	21.7	J-Field	40204	2000	MAY	17
	4	12.5	J-Field	992B204	1999	APR	27
	5	10.6	Cluster 3	992CT02	1999	SEP	14
	6	10.3	Cylburn Arboretum	992BA01	1999	JUL	27
	7	8.8	J-Field	20505	2000	JUN	10
	8	7.8	J-Field	992A200	1999	MAR	11
	9	7.4	J-Field	40101	2000	APR	6
	10	7.2	J-Field	20102	2000	SEP	28
Dibromomethane	1	137.7	J-Field	20102	2000	SEP	28
	2	96.3	J-Field	20104	2000	MAY	17
	3	53.1	J-Field	40104	2000	MAY	17
	4	25.2	Cluster 3	20201	2000	AUG	3
	5	21.4	J-Field	20204	2000	FEB	17
	6	16.4	J-Field	20505	2000	JUN	10
	7	15.7	J-Field	992B204	1999	APR	27
	8	13.4	J-Field	40204	2000	MAY	17
	9	9.4	J-Field	20101	2000	AUG	1
	10	8.7	Cluster 3	Estuary Ambient	2000	AUG	3
1,3-Dichloro-1-propene	1	251.4	Shawsville	992SV02	1999	SEP	24
	2	45.1	J-Field	992T403	1999	APR	13
	3	29.3	J-Field	40204	2000	MAY	17
	4	15.1	J-Field	992A200	1999	MAR	11
	5	11.7	J-Field	20206	2000	SEP	13
	6	11.3	J-Field	992B204	1999	APR	27
	7	10.1	Cluster 3	20201	2000	AUG	3
	8	7.4	Rumsey Mansion	992RI02	1999	SEP	25
	9	5.6	J-Field	20205	2000	JUN	1
	10	5.3	J-Field	20505	2000	JUN	10
Toluene	1	474789.2	Shawsville	992SV02	1999	SEP	24
	2	221829.0	Cluster 3	20201	2000	AUG	3
	3	122386.5	J-Field	20103	2000	OCT	3
	4	13354.3	J-Field	20102	2000	SEP	28
	5	10489.2	J-Field	40303	2000	MAY	3
	6	10068.3	Lorh's Orchard		1998	JUN	9
	7	8852.7	J-Field	40101	2000	APR	6
	8	8602.3	Cluster 3	Estuary Ambient	2000	AUG	3
	9	8401.8	J-Field	20206	2000	SEP	13
	10	7973.3	J-Field	20402	2000	APR	19
trans-1,3-Dichloro-1-propene	1	5235.4	J-Field	20103	2000	OCT	3
	2	279.3	Shawsville	992SV02	1999	SEP	24
	3	201.8	J-Field	20102	2000	SEP	28
	4	175.8	J-Field	40101	2000	APR	6
	5	94.7	J-Field	20303	2000	MAY	3
	6	82.6	J-Field	40104	2000	MAY	17
	7	67.5	J-Field	40303	2000	MAY	3
	8	53.9	J-Field	40204	2000	MAY	17
	9	52.3	J-Field	40302	2000	APR	19
	10	49.7	J-Field	20504	2000	MAY	17
1,1,2-Trichloroethane	1	1338.4	J-Field	20102	2000	SEP	28
	2	1227.7	Shawsville	992SV02	1999	SEP	24

	3	157.6	J-Field	992T403	1999	APR	13
	4	51.2	Cluster 3	20201	2000	AUG	3
	5	45.0	J-Field	20305	2000	JUN	1
	6	38.9	J-Field	20303	2000	MAY	3
	7	32.1	Cluster 13	9921302a	1999	SEP	14
	8	18.9	J-Field	20405	2000	JUN	1
	9	15.4	J-Field	992B204	1999	APR	27
	10	13.2	J-Field	40204	2000	MAY	17
1,3-Dichloropropane	1	52.3	J-Field	992B204	1999	APR	27
	2	10.1	Cluster 3	20201	2000	AUG	3
	3	6.3	J-Field	992D200	1999	MAR	11
	4	5.4	J-Field	992C205	1999	OCT	16
	5	3.8	J-Field	99TT000	1999	MAR	11
	6	3.5	Jones Farm	992JF02	1999	SEP	14
	7	3.1	J-Field	992A204	1999	APR	27
	8	2.8	J-Field	20102	2000	SEP	28
	9	2.4	J-Field	J-Field AIR	1999	JUN	28
	10	2.4	Conowingo Orchard	992CC01	1999	JUL	27
Tetrachloroethene	1	17062.4	Cluster 3	20201	2000	AUG	3
	2	6510.2	Shawsville	992SV02	1999	SEP	24
	3	1547.7	J-Field		1998	JUN	27
	4	1009.6	Youth Center		1996	AUG	23
	5	915.2	Beach Point		1996	AUG	23
	6	811.9	J-Field	20103	2000	OCT	3
	7	695.0	East Branch Canal Creek		1996	AUG	23
	8	666.3	J-Field	994T404	1999	APR	28
	9	612.0	G-Street		1996	AUG	23
	10	605.1	Lorh's Orchard		1998	JUN	9
Dibromochloromethane	1	1770.3	Shawsville	992SV02	1999	SEP	24
	2	113.9	Cluster 3	20201	2000	AUG	3
	3	42.9	J-Field	992B204	1999	APR	27
	4	33.8	J-Field	40206	2000	SEP	13
	5	19.2	J-Field	20206	2000	SEP	13
	6	16.4	Cluster 3	992CT01	1999	AUG	17
	7	13.5	J-Field	20503	2000	MAY	3
	8	10.5	J-Field	992D204	1999	APR	27
	9	7.9	J-Field	992D200	1999	MAR	11
	10	6.1	Cluster 13	992CT01	1999	JUL	23
1,2-Dibromoethane	1	66.6	J-Field	992B204	1999	APR	27
	2	22.6	J-Field	992A204	1999	APR	27
	3	13.6	J-Field	992D203	1999	APR	13
	4	12.0	Jones Farm	992JF02	1999	SEP	14
	5	4.3	J-Field	992C205	1999	OCT	16
	6	3.5	J-Field	992D200	1999	MAR	11
	7	2.8	J-Field	992T004	1999	APR	28
	8	2.4	J-Field	99TT000	1999	MAR	11
	9	2.4	J-Field	992E203	1999	APR	14
	10	2.1	J-Field	992E204	1999	APR	27
Chlorobenzene	1	265.4	Shawsville	992SV02	1999	SEP	24
	2	117.5	Cluster 3	Estuary Ambient	2000	AUG	3
	3	103.3	Cluster 3	20201	2000	AUG	3
	4	79.1	J-Field	40206	2000	SEP	13

	5	78.3	J-Field	994T004	1999	APR	28
	6	74.9	J-Field	40103	2000	MAY	3
	7	60.5	J-Field	20205	2000	JUN	1
	8	54.5	J-Field	20103	2000	OCT	3
	9	50.3	J-Field	992T004	1999	APR	28
	10	49.1	J-Field	20305	2000	JUN	1
1,1,1,2-Tetrachloroethane	1	37.2	J-Field	992A204	1999	APR	27
	2	36.7	J-Field	992B204	1999	APR	27
	3	14.1	J-Field	992D200	1999	MAR	11
	4	10.9	J-Field	992D203	1999	APR	13
	5	6.3	J-Field	99TT000	1999	MAR	11
	6	6.1	J-Field	992E204	1999	APR	27
	7	5.3	J-Field	992E202	1999	MAR	23
	8	4.7	J-Field	992F001	1999	JUN	19
	9	3.9	J-Field	992T004	1999	APR	28
	10	3.9	Jones Farm	992JF02	1999	SEP	14
Ethylbenzene	1	321013.1	Shawsville	992SV02	1999	SEP	24
	2	37056.9	Cluster 3	20201	2000	AUG	3
	3	5822.2	Rumsey Mansion	992RI02	1999	SEP	25
	4	5623.2	Tower Hill	992TH02	1999	SEP	24
	5	4622.2	O-Field		1998	SEP	29
	6	4065.5	Otter Creek	992OP01	1999	JUL	23
	7	4016.1	Jones Farm	992JF01	1999	JUL	23
	8	3253.4	Shawsville	992SV01	1999	JUL	27
	9	3251.1	J-Field	20102	2000	SEP	28
	10	3171.2	Rumsey Mansion	992RI01	1999	JUL	23
m,p-Xylenes	1	222693.4	Shawsville	992SV02	1999	SEP	24
	2	56534.8	Cluster 3	20201	2000	AUG	3
	3	4393.5	J-Field	40303	2000	MAY	3
	4	3462.8	J-Field	20102	2000	SEP	28
	5	3093.3	J-Field	20402	2000	APR	19
	6	2188.1	J-Field	40104	2000	MAY	17
	7	1612.9	J-Field	20103	2000	OCT	3
	8	1513.5	J-Field	20506	2000	SEP	13
	9	1413.6	Tower Hill	992TH02	1999	SEP	24
	10	1227.2	J-Field	20406	2000	SEP	13
o-Xylene	1	33003.1	Shawsville	992SV02	1999	SEP	24
	2	20646.0	Cluster 3	20201	2000	AUG	3
	3	1706.9	J-Field	40303	2000	MAY	3
	4	1568.0	J-Field	20102	2000	SEP	28
	5	1303.2	J-Field	20103	2000	OCT	3
	6	1100.6	J-Field	20402	2000	APR	19
	7	769.8	J-Field	40104	2000	MAY	17
	8	537.0	Tower Hill	992TH02	1999	SEP	24
	9	494.9	J-Field	20406	2000	SEP	13
	10	439.1	J-Field	992F001	1999	JUN	19
Styrene	1	172210.1	Shawsville	992SV02	1999	SEP	24
	2	11224.9	J-Field	20506	2000	SEP	13
	3	6727.6	J-Field	992B204	1999	APR	27
	4	1717.0	Cluster 3	20201	2000	AUG	3
	5	894.6	J-Field	992D204	1999	APR	27

	6	695.7	J-Field	20103	2000	OCT	3
	7	659.4	Rumsey Mansion	992RI02	1999	SEP	25
	8	618.6	Churchville	992CV03	1999	SEP	24
	9	457.2	Tower Hill	992TH02	1999	SEP	24
	10	422.8	Cluster 3	992CT03	1999	OCT	13
Isopropylbenzene	1	2063.4	J-Field	20506	2000	SEP	13
	2	1327.8	Shawsville	992SV02	1999	SEP	24
	3	104.4	J-Field	992B204	1999	APR	27
	4	86.2	J-Field	40303	2000	MAY	3
	5	78.7	Cluster 3	992CT01	1999	AUG	17
	6	70.3	Cluster 3	20201	2000	AUG	3
	7	65.8	J-Field	40103	2000	MAY	3
	8	63.8	J-Field	992D204	1999	APR	27
	9	62.6	J-Field	40104	2000	MAY	17
	10	58.7	J-Field	20103	2000	OCT	3
Tribromomethane	1	43.4	Jones Farm	992JF02	1999	SEP	14
	2	42.2	J-Field	992D203	1999	APR	13
	3	36.8	Cluster 3	20201	2000	AUG	3
	4	28.4	J-Field	992B204	1999	APR	27
	5	24.4	J-Field	992A200	1999	MAR	11
	6	10.1	J-Field	J-Field AIR	1999	JUN	28
	7	7.3	J-Field	992A204	1999	APR	27
	8	6.9	J-Field	992D200	1999	MAR	11
	9	6.9	J-Field	99TT000	1999	MAR	11
	10	6.3	J-Field	992T004	1999	APR	28
1,1,2,2-Tetrachloroethane	1	2376.4	J-Field	990T403	1999	APR	13
	2	2005.2	J-Field	994T404	1999	APR	28
	3	813.0	Shawsville	992SV02	1999	SEP	24
	4	141.9	J-Field	40105	2000	JUN	1
	5	124.0	J-Field	992A204	1999	APR	27
	6	120.3	Jones Farm	992JF02	1999	SEP	14
	7	119.6	J-Field	40104	2000	MAY	17
	8	117.8	J-Field	20203	2000	MAY	3
	9	102.8	J-Field	992D203	1999	APR	13
	10	101.9	J-Field	40206	2000	SEP	13
1-Bromo-4-fluorobenzene	1	1575113.1	Shawsville	992SV02	1999	SEP	24
	2	38574.9	Cluster 3	20201	2000	AUG	3
	3	11767.2	Lorh's Orchard	992LO02	1999	SEP	14
	4	7578.7	J-Field	992B205	1999	OCT	16
	5	7509.9	J-Field	992AZ05	1999	OCT	16
	6	7350.3	J-Field	992D202	1999	MAR	23
	7	7288.4	Rumsey Mansion	992RI02	1999	SEP	25
	8	7121.6	J-Field	992C205	1999	OCT	16
	9	7109.0	J-Field	992F205	1999	AUG	6
	10	7036.9	Cylburn Arboretum	992AB02	1999	SEP	25
n-Propylbenzene	1	8917.0	Shawsville	992SV02	1999	SEP	24
	2	474.4	J-Field	40303	2000	MAY	3
	3	223.7	J-Field	20103	2000	OCT	3
	4	131.3	Cluster 3	20201	2000	AUG	3
	5	99.9	J-Field	20402	2000	APR	19
	6	60.0	Tower Hill	992TH02	1999	SEP	24

	7	59.5	Rumsey Mansion	992RI02	1999	SEP	25
	8	59.2	J-Field	20406	2000	SEP	13
	9	46.6	J-Field	40302	2000	APR	19
	10	42.6	J-Field	20504	2000	MAY	17
Bromobenzene	1	2064.3	J-Field	20305	2000	JUN	1
	2	886.8	J-Field	40303	2000	MAY	3
	3	539.3	Shawsville	992SV02	1999	SEP	24
	4	213.3	J-Field	40305	2000	JUN	1
	5	204.2	J-Field	20103	2000	OCT	3
	6	96.1	J-Field	20205	2000	JUN	1
	7	51.0	Jones Farm	992JF02	1999	SEP	14
	8	48.7	J-Field	992A204	1999	APR	27
	9	40.5	J-Field	40103	2000	MAY	3
	10	39.5	J-Field	992A200	1999	MAR	11
1,3,5-Trimethylbenzene	1	1040740.0	Shawsville	992SV02	1999	SEP	24
	2	4672.6	J-Field	40303	2000	MAY	3
	3	929.9	Rumsey Mansion	992RI02	1999	SEP	25
	4	619.4	J-Field	20402	2000	APR	19
	5	397.9	J-Field	20404	2000	MAY	17
	6	369.9	Churchville	992CV03	1999	SEP	24
	7	299.7	Cluster 3	20201	2000	AUG	3
	8	101.9	Tower Hill	992TH02	1999	SEP	24
	9	95.8	J-Field	40302	2000	APR	19
	10	78.2	J-Field	20103	2000	OCT	3
2-Chlorotoluene	1	686.8	Shawsville	992SV02	1999	SEP	24
	2	404.4	J-Field	40303	2000	MAY	3
	3	345.4	J-Field	992B204	1999	APR	27
	4	47.9	J-Field	40302	2000	APR	19
	5	31.5	J-Field	992A204	1999	APR	27
	6	26.1	J-Field	992A200	1999	MAR	11
	7	12.9	J-Field	40103	2000	MAY	3
	8	7.9	Tower Hill	992TH02	1999	SEP	24
	9	6.7	J-Field	40305	2000	JUN	1
	10	6.6	J-Field	992F001	1999	JUN	19
4-Chlorotoluene	1	686.3	Shawsville	992SV02	1999	SEP	24
	2	404.4	J-Field	40303	2000	MAY	3
	3	47.9	J-Field	40302	2000	APR	19
	4	38.3	J-Field	992A204	1999	APR	27
	5	32.7	J-Field	992B204	1999	APR	27
	6	32.4	J-Field	992A200	1999	MAR	11
	7	21.5	J-Field	40103	2000	MAY	3
	8	14.9	Jones Farm	992JF02	1999	SEP	14
	9	12.5	J-Field	992D203	1999	APR	13
	10	11.0	J-Field	J-Field AIR	1999	JUN	28
tert-Butylbenzene	1	565.5	J-Field	40303	2000	MAY	3
	2	219.1	Shawsville	992SV02	1999	SEP	24
	3	55.7	J-Field	40302	2000	APR	19
	4	52.0	J-Field	40103	2000	MAY	3
	5	39.0	J-Field	992B204	1999	APR	27
	6	37.9	J-Field	20103	2000	OCT	3
	7	25.0	J-Field	20504	2000	MAY	17
	8	23.1	J-Field	992A200	1999	MAR	11

	9	20.2	J-Field	990T403	1999	APR	13
	10	18.9	J-Field	20505	2000	JUN	10
1,2,4-Trimethylbenzene	1	9112.8	Shawsville	992SV02	1999	SEP	24
	2	4024.7	J-Field	40303	2000	MAY	3
	3	724.9	Cluster 3	20201	2000	AUG	3
	4	378.5	J-Field	40302	2000	APR	19
	5	262.0	J-Field	20402	2000	APR	19
	6	161.7	J-Field	20504	2000	MAY	17
	7	136.4	J-Field	20103	2000	OCT	3
	8	118.3	J-Field	20505	2000	JUN	10
	9	92.4	Jones Farm	992JF02	1999	SEP	14
	10	76.4	J-Field	20102	2000	SEP	28
Benezaldehyde	1	874795.3	Shawsville	992SV02	1999	SEP	24
	2	83263.6	Cluster 3	20201	2000	AUG	3
	3	52977.1	Rumsey Mansion	992RI02	1999	SEP	25
	4	16870.4	O-Field		1998	JUN	2
	5	15377.6	J-Field	20506	2000	SEP	13
	6	13208.7	Rumsey Mansion	992RI01	1999	JUL	23
	7	10797.2	D-Field		1998	AUG	9
	8	10270.3	Aberdeen Post		1998	AUG	10
	9	8750.5	Cluster 3	Estuary Ambient	2000	AUG	3
	10	8497.2	D-Field		1998	JUN	3
sec-Butylbenzene	1	4816.2	Shawsville	992SV02	1999	SEP	24
	2	3616.7	Rumsey Mansion	992RI02	1999	SEP	25
	3	3078.8	Cluster 3	20201	2000	AUG	3
	4	2157.6	Rumsey Mansion	992RI01	1999	JUL	23
	5	1226.6	Cluster 3	992CT01	1999	AUG	17
	6	562.7	J-Field	20506	2000	SEP	13
	7	529.2	J-Field	992F206	1999	SEP	10
	8	453.3	J-Field	20103	2000	OCT	3
	9	359.4	Churchville	992CV03	1999	SEP	24
	10	319.3	Cylburn Arboretum	992BA01	1999	JUL	27
Isopropyltoluene	1	33024.6	Shawsville	992SV02	1999	SEP	24
	2	2333.8	J-Field	992B204	1999	APR	27
	3	952.0	Cluster 3	20201	2000	AUG	3
	4	326.9	J-Field	20305	2000	JUN	1
	5	202.8	J-Field	40303	2000	MAY	3
	6	122.7	Lorh's Orchard	992LO02	1999	SEP	14
	7	113.1	Otter Creek	992OP01	1999	JUL	23
	8	100.0	Rumsey Mansion	992RI02	1999	SEP	25
	9	60.5	Jones Farm	992JF02	1999	SEP	14
	10	46.0	J-Field	40305	2000	JUN	1
1,3-Dichlorobenzene	1	1503.6	Shawsville	992SV02	1999	SEP	24
	2	1168.0	J-Field	40303	2000	MAY	3
	3	270.2	J-Field	20103	2000	OCT	3
	4	110.7	J-Field	20505	2000	JUN	10
	5	91.7	J-Field	20404	2000	MAY	17
	6	75.7	J-Field	20504	2000	MAY	17
	7	74.0	J-Field	992B204	1999	APR	27
	8	51.7	J-Field	992A204	1999	APR	27
	9	46.8	J-Field	20406	2000	SEP	13
	10	43.9	J-Field	992A200	1999	MAR	11

1,4-Dichlorobenzene	1	5584.6	D-Field		1998	JUN	3
	2	1857.2	O-Field		1998	JUN	2
	3	1503.6	Shawsville	992SV02	1999	SEP	24
	4	1128.2	J-Field	40303	2000	MAY	3
	5	390.0	Churchville		1997	AUG	9
	6	256.0	J-Field	20103	2000	OCT	3
	7	139.3	J-Field		1997	JUL	31
	8	128.6	O-Field		1997	JUL	31
	9	124.5	National Guard Armory		1997	AUG	12
	10	119.7	Youth Center		1996	AUG	23
n-Butylbenzene	1	541.6	J-Field	992B204	1999	APR	27
	2	405.2	Shawsville	992SV02	1999	SEP	24
	3	312.3	J-Field	40303	2000	MAY	3
	4	58.4	J-Field	20305	2000	JUN	1
	5	46.2	J-Field	992D203	1999	APR	13
	6	45.4	J-Field	992A204	1999	APR	27
	7	42.6	J-Field	992E204	1999	APR	27
	8	40.2	Jones Farm	992JF02	1999	SEP	14
	9	37.0	J-Field	40302	2000	APR	19
	10	35.7	J-Field	992A200	1999	MAR	11
1,2-4-Dichlorobenzene	1	1106185.9	Shawsville	992SV02	1999	SEP	24
	2	23224.4	Cluster 3	20201	2000	AUG	3
	3	5955.2	J-Field	40204	2000	MAY	17
	4	5856.6	Eastern Shore	20301	2000	AUG	2
	5	4809.8	Lorh's Orchard	992LO02	1999	SEP	14
	6	3572.3	J-Field	20101	2000	AUG	1
	7	3292.5	Cluster 3	Estuary Ambient	2000	AUG	3
	8	3206.2	J-Field	20506	2000	SEP	13
	9	3172.6	J-Field	40106	2000	JUN	13
	10	3090.1	J-Field	992AZ05	1999	OCT	16
1,2-Dichlorobenzene	1	186.5	J-Field	992B204	1999	APR	27
	2	73.4	J-Field	992A204	1999	APR	27
	3	61.0	J-Field	992D203	1999	APR	13
	4	57.1	Jones Farm	992JF02	1999	SEP	14
	5	52.5	J-Field	992A200	1999	MAR	11
	6	50.9	J-Field	992D200	1999	MAR	11
	7	44.7	J-Field	992E204	1999	APR	27
	8	34.9	J-Field	992F001	1999	JUN	19
	9	31.8	J-Field	40103	2000	MAY	3
	10	22.5	J-Field	J-Field AIR	1999	JUN	28
Hexachloroethane	1	571.4	J-Field	40303	2000	MAY	3
	2	456.8	Shawsville	992SV02	1999	SEP	24
	3	321.3	J-Field	992B204	1999	APR	27
	4	144.8	Cluster 3	20201	2000	AUG	3
	5	130.3	J-Field	20305	2000	JUN	1
	6	53.5	Jones Farm	992JF02	1999	SEP	14
	7	34.2	J-Field	40205	2000	JUN	1
	8	31.7	J-Field	992A204	1999	APR	27
	9	27.4	J-Field	40302	2000	APR	19
	10	25.7	J-Field	40204	2000	MAY	17
Acetophenone	1	72643.1	Shawsville	992SV02	1999	SEP	24
	2	1032.7	J-Field	40303	2000	MAY	3

	3	841.7	D-Field		1998	JUN	3
	4	796.1	J-Field		1998	JUN	27
	5	646.9	J-Field		1998	AUG	8
	6	577.5	G-Street		1996	AUG	23
	7	563.3	J-Field	J-Field AIR	1999	JUN	28
	8	544.4	J-Field	992E204	1999	APR	27
	9	537.6	J-Field		1998	JUN	27
	10	516.3	J-Field	992A200	1999	MAR	11
1,2-Dibromo-3-chloropropane	1	3017.4	J-Field	992B204	1999	APR	27
	2	215.7	J-Field	992A204	1999	APR	27
	3	156.6	J-Field	992A200	1999	MAR	11
	4	118.1	Jones Farm	992JF02	1999	SEP	14
	5	112.4	J-Field	992E204	1999	APR	27
	6	109.3	J-Field	992D203	1999	APR	13
	7	71.9	J-Field	J-Field AIR	1999	JUN	28
	8	58.8	J-Field	992F001	1999	JUN	19
	9	52.1	Youth Center	992YC01	1999	JUL	23
	10	30.8	J-Field	992D200	1999	MAR	11
1,2,4-Trichlorobenzene	1	194.3	J-Field	992A204	1999	APR	27
	2	189.0	J-Field	992E204	1999	APR	27
	3	146.7	J-Field	992D203	1999	APR	13
	4	130.5	J-Field	992A200	1999	MAR	11
	5	120.6	J-Field	992D200	1999	MAR	11
	6	89.4	J-Field	J-Field AIR	1999	JUN	28
	7	68.6	Jones Farm	992JF02	1999	SEP	14
	8	41.0	J-Field	992F001	1999	JUN	19
	9	15.5	J-Field	20102	2000	SEP	28
	10	12.1	Conowingo Orchard	992CC01	1999	JUL	27
Naphthalene	1	3441.5	Shawsville	992SV02	1999	SEP	24
	2	1493.3	J-Field	40303	2000	MAY	3
	3	412.5	Bush River		1997	AUG	29
	4	335.3	J-Field	992A204	1999	APR	27
	5	328.0	J-Field	992E204	1999	APR	27
	6	276.7	J-Field	992D203	1999	APR	13
	7	270.0	Bush River		1997	AUG	31
	8	254.6	J-Field	992A200	1999	MAR	11
	9	226.4	G-Street		1996	AUG	23
	10	218.7	J-Field	J-Field AIR	1999	JUN	28
1,2,3-Trichlorobenzene	1	305.5	J-Field	992E204	1999	APR	27
	2	292.8	J-Field	992A204	1999	APR	27
	3	255.9	J-Field	992D203	1999	APR	13
	4	220.4	J-Field	992A200	1999	MAR	11
	5	134.6	J-Field	J-Field AIR	1999	JUN	28
	6	125.7	J-Field	992D200	1999	MAR	11
	7	122.6	J-Field	992F001	1999	JUN	19
	8	100.2	Youth Center	992YC01	1999	JUL	23
	9	84.1	Jones Farm	992JF02	1999	SEP	14
	10	9.8	Cluster 3	20201	2000	AUG	3

TABLE 8.9.2 Ten Highest Concentrations for Volatile Organics in Hive Air
(ranked from highest to lowest, 1-10, Respectively)

	Rank	Conc (ng/m3)	Location	Sample	Year	Month	Day
1,1-Dichloroethene	1	8437.4	J-Field	990E304	1999	APR	27
	2	5697.3	J-Field	990D304	1999	APR	27
	3	4663.3	J-Field	990D101	1999	MAR	23
	4	4347.2	J-Field	990E104	1999	APR	27
	5	3951.5	J-Field	990D104	1999	APR	27
	6	3423.2	J-Field	990A103	1999	APR	13
	7	3344.5	J-Field	990C303	1999	APR	13
	8	3078.3	J-Field	990A304	1999	APR	27
	9	3040.5	J-Field	990D105	1999	OCT	16
	10	2688.2	J-Field	990D103	1999	APR	13
Dichloromethane	1	328285.5	Cluster 3	3701	2000	MAY	3
	2	292162.0	Cluster 3	4801	2000	AUG	3
	3	232019.4	J-Field	3403	2000	OCT	3
	4	166797.3	J-Field	801	2000	APR	6
	5	147344.9	Cluster 3	3101	2000	AUG	3
	6	136531.4	Cluster 3	Estuary	2000	AUG	3
	7	101551.4	J-Field	1203	2000	MAY	3
	8	86297.4	Eastern Shore	3601	2000	AUG	2
	9	86236.1	J-Field	503	2000	MAY	3
	10	86175.5	Cluster 3	4201	2000	AUG	3
trans-1,2-Dichloroethene	1	164.4	J-Field	603	2000	MAY	3
	2	72.8	J-Field	503	2000	MAY	3
	3	58.9	J-Field	205	2000	JUN	1
	4	49.0	J-Field	403	2000	MAY	3
	5	41.3	J-Field	990A304	1999	APR	27
	6	19.4	J-Field	605	2000	JUN	1
	7	15.6	J-Field	990D101	1999	MAR	23
	8	12.9	J-Field	4901	2000	AUG	1
	9	12.2	J-Field	5001	2000	AUG	1
	10	12.0	J-Field	606	2000	SEP	13
1,1-Dichloroethane	1	31.2	J-Field	205	2000	JUN	1
	2	22.1	Cluster 3	4801	2000	AUG	3
	3	13.1	Eastern Shore	3601	2000	AUG	2
	4	12.3	J-Field	1505	2000	JUN	1
	5	11.9	Cluster 3	3701	2000	MAY	3
	6	11.1	J-Field	1005	2000	JUN	1
	7	11.0	Cluster 3	3101	2000	AUG	3
	8	7.3	Eastern Shore	4301	2000	MAY	2
	9	6.9	J-Field	4901	2000	AUG	1
	10	6.7	J-Field	105	2000	JUN	1
2,2-Dichloropropane	1	1751.3	J-Field	1503	2000	MAY	3
	2	1340.0	Cluster 3	9904801	1999	AUG	17
	3	942.3	J-Field	1002	2000	APR	19
	4	865.1	J-Field	1103	2000	MAY	3
	5	650.4	J-Field	403	2000	MAY	3
	6	38.0	J-Field	1203	2000	MAY	3
	7	22.8	J-Field	801	2000	APR	6

	8	21.4	J-Field	402	2000	APR	19
	9	15.4	J-Field	605	2000	JUN	1
	10	10.9	J-Field	990F201	1999	JUN	19
cis-1,2-Dichloroethene	1	38597.1	Eastern Shore	4301	2000	MAY	2
	2	33002.0	J-Field	4101	2000	AUG	1
	3	26797.8	Eastern Shore	3601	2000	AUG	2
	4	25982.9	Eastern Shore	2901	2000	AUG	2
	5	21488.0	J-Field	306	2000	SEP	13
	6	21032.9	Cluster 3	3101	2000	AUG	3
	7	16096.1	J-Field	1203	2000	MAY	3
	8	15664.7	J-Field	990D303	1999	APR	13
	9	13949.3	Eastern Shore	4001	2000	AUG	2
	10	13771.3	J-Field	3503	2000	OCT	3
Trichloromethane	1	3073.3	J-Field	1102	2000	APR	19
	2	2365.9	J-Field	502	2000	APR	19
	3	1999.8	J-Field	990D205	1999	OCT	16
	4	1285.2	J-Field	1302	2000	APR	19
	5	996.7	J-Field	990A303	1999	APR	13
	6	873.2	Cluster 3	Estuary	2000	AUG	3
	7	758.9	Eastern Shore	3601	2000	AUG	2
	8	738.2	J-Field	1005	2000	JUN	1
	9	722.7	J-Field	990E305	1999	OCT	16
	10	720.3	J-Field	1505	2000	JUN	1
Bromochloromethane	1	86.7	J-Field	205	2000	JUN	1
	2	13.2	J-Field	105	2000	JUN	1
	3	5.9	J-Field	801	2000	APR	6
	4	5.6	Cluster 3	2702	2000	SEP	28
	5	4.8	Cluster 3	3701	2000	MAY	3
	6	4.0	Cluster 3	2701	2000	AUG	3
	7	3.4	J-Field	4901	2000	AUG	1
	8	2.4	J-Field	3403	2000	OCT	3
	9	2.3	J-Field	2602	2000	SEP	28
	10	2.3	Eastern Shore	4302	2000	SEP	27
1,1,1-Trichloroethane	1	15980.9	J-Field	990D205	1999	OCT	16
	2	8054.5	J-Field	1102	2000	APR	19
	3	4516.4	Churchville	9904403	1999	SEP	24
	4	4140.5	J-Field	502	2000	APR	19
	5	3172.6	J-Field	1302	2000	APR	19
	6	3155.2	J-Field	990C305	1999	OCT	16
	7	3090.7	J-Field	990B205	1999	OCT	16
	8	2575.1	Cluster 3	9904603	1999	OCT	13
	9	2320.1	J-Field	990D105	1999	OCT	16
	10	2043.1	Cluster 3	9904203	1999	OCT	13
1,1-Dichloropropane	1	463.7	J-Field	803	2000	MAY	3
	2	402.6	J-Field	603	2000	MAY	3
	3	338.5	J-Field	303	2000	MAY	3
	4	307.8	J-Field	403	2000	MAY	3
	5	220.2	J-Field	103	2000	MAY	3
	6	83.6	J-Field	203	2000	MAY	3
	7	58.2	J-Field	503	2000	MAY	3
	8	27.7	J-Field	703	2000	MAY	3
	9	19.8	J-Field	801	2000	APR	6

	10	15.3	J-Field	990E203	1999	APR	13
Tetrachloromethane	1	2527.6	J-Field		1998	AUG	8
	2	2145.6	D-Field		1998	AUG	9
	3	1584.2	Shawsville		1998	JUL	7
	4	1396.8	J-Field		1998	AUG	8
	5	1311.1	WBranch Canal Creek		1997	JUL	20
	6	1151.1	D-Field		1998	AUG	9
	7	1091.1	D-Field		1998	AUG	9
	8	1035.0	J-Field		1998	AUG	8
	9	1013.1	Carrol Island		1998	AUG	7
	10	1004.5	J-Field		1998	AUG	8
1,2-Dichloroethane	1	17983.1	Cluster 3	3701	2000	MAY	3
	2	9300.7	Cluster 3	2701	2000	AUG	3
	3	9088.8	Eastern Shore	3601	2000	AUG	2
	4	9006.8	Cluster 3	4801	2000	AUG	3
	5	7387.8	Cluster 3	4201	2000	AUG	3
	6	5728.0	Eastern Shore	4301	2000	MAY	2
	7	5111.7	J-Field	3501	2000	AUG	1
	8	5047.0	J-Field	4901	2000	AUG	1
	9	4308.1	Eastern Shore	4001	2000	AUG	2
	10	3359.2	Cluster 3	Estuary	2000	AUG	3
Benzene	1	21982.4	Cluster 3	3701	2000	MAY	3
	2	13193.6	Cluster 3	2701	2000	AUG	3
	3	12822.3	Cluster 3	4801	2000	AUG	3
	4	9150.1	Eastern Shore	4001	2000	AUG	2
	5	8070.4	Cluster 3	4201	2000	AUG	3
	6	7541.4	J-Field	4901	2000	AUG	1
	7	7075.0	Eastern Shore	3601	2000	AUG	2
	8	5494.2	Eastern Shore	4401	2000	AUG	2
	9	4478.7	J-Field	5001	2000	AUG	1
	10	4387.1	Cluster 3	Estuary	2000	AUG	3
Trichloroethene	1	13923.8	Churchville		1996	AUG	25
	2	3599.4	Churchville		1996	AUG	25
	3	1917.4	Youth Center		1996	AUG	23
	4	1186.5	J-Field		1997	JUL	15
	5	1016.3	O-Field		1996	SEP	2
	6	913.3	O-Field		1997	JUL	15
	7	743.8	J-Field	402	2000	APR	19
	8	723.4	J-Field		1997	JUL	31
	9	680.0	J-Field	1103	2000	MAY	3
	10	602.2	J-Field	1102	2000	APR	19
1,2-Dichloropropane	1	19.6	J-Field	1005	2000	JUN	1
	2	13.4	Eastern Shore	2901	2000	AUG	2
	3	12.9	J-Field	990E203	1999	APR	14
	4	8.4	J-Field	990A104	1999	APR	27
	5	6.0	Eastern Shore	4301	2000	MAY	2
	6	5.9	Churchville	990CV601	1999	JUN	24
	7	5.6	Eastern Shore	2801	2000	AUG	20
	8	4.6	J-Field	990A200	1999	MAR	11
	9	4.3	J-Field	990A304	1999	APR	27
	10	4.3	J-Field	990D300	1999	MAR	11
Bromodichloromethane	1	49.2	J-Field	1102	2000	APR	19

	2	39.0	Jones Farm	9903201	1999	JUL	23
	3	36.9	Eastern Shore	2901	2000	AUG	2
	4	14.7	J-Field	990E203	1999	APR	13
	5	14.6	Silver Lake	9904601	1999	JUL	27
	6	14.3	Eastern Shore	4301	2000	MAY	2
	7	13.5	J-Field	505	2000	JUN	1
	8	13.2	J-Field	305	2000	JUN	1
	9	12.0	J-Field	1304	2000	MAY	17
	10	11.2	J-Field	1106	2000	SEP	13
Dibromomethane	1	4897.7	Eastern Shore	4402	2000	SEP	27
	2	249.9	J-Field	205	2000	JUN	1
	3	67.3	J-Field	105	2000	JUN	1
	4	29.9	Eastern Shore	2901	2000	AUG	2
	5	20.2	J-Field	990E203	1999	APR	14
	6	18.1	J-Field	2602	2000	SEP	28
	7	17.4	J-Field	305	2000	JUN	1
	8	6.9	J-Field	990A104	1999	APR	27
	9	6.7	Eastern Shore	4301	2000	MAY	2
	10	6.0	J-Field	104	2000	MAY	17
1,3-Dichloro-1-propene	1	391.4	Eastern Shore	4301	2000	MAY	2
	2	79.3	Eastern Shore	2901	2000	AUG	2
	3	42.1	J-Field	403	2000	MAY	3
	4	41.0	Cluster 3	9904202	1999	SEP	14
	5	22.7	J-Field	1405	2000	JUN	1
	6	22.6	J-Field	405	2000	JUN	1
	7	15.5	J-Field	305	2000	JUN	1
	8	14.4	J-Field	1006	2000	SEP	13
	9	11.8	J-Field	990E203	1999	APR	13
	10	11.6	J-Field	990E203	1999	APR	14
Toluene	1	184471.3	J-Field	3403	2000	OCT	3
	2	173662.0	Eastern Shore	2901	2000	AUG	2
	3	164498.9	J-Field	3503	2000	OCT	3
	4	137875.1	J-Field	3003	2000	JAN	3
	5	117080.4	J-Field	2603	2000	JAN	3
	6	98596.9	J-Field	5003	2000	OCT	3
	7	95000.0	J-Field	4903	2000	OCT	3
	8	86831.2	J-Field	4103	2000	OCT	3
	9	32116.0	Eastern Shore	4001	2000	AUG	2
	10	30863.9	J-Field	406	2000	SEP	13
trans-1,3-Dichloro-1-propene	1	125086.1	Eastern Shore	4301	2000	MAY	2
	2	7292.8	J-Field	3403	2000	OCT	3
	3	6201.2	J-Field	3503	2000	OCT	3
	4	5489.0	J-Field	3003	2000	JAN	3
	5	4898.1	J-Field	104	2000	MAY	17
	6	4738.0	J-Field	2603	2000	JAN	3
	7	3502.2	Youth Center	9902801	1999	JUL	23
	8	3302.6	J-Field	5003	2000	OCT	3
	9	3159.8	J-Field	4903	2000	OCT	3
	10	3041.2	J-Field	4103	2000	OCT	3
1,1,2-Trichloroethane	1	1223.6	J-Field	3502	2000	SEP	28
	2	859.9	J-Field	3402	2000	SEP	28

	3	816.6	J-Field	990F306	1999	SEP	10
	4	784.5	J-Field	5002	2000	SEP	28
	5	87.2	J-Field	406	2000	SEP	13
	6	65.4	J-Field	3003	2000	JAN	3
	7	57.8	Eastern Shore	2901	2000	AUG	2
	8	57.7	J-Field	103	2000	MAY	3
	9	53.8	J-Field	4102	2000	SEP	28
	10	50.8	J-Field	4902	2000	SEP	28
1,3-Dichloropropane	1	1107.1	Eastern Shore	4301	2000	MAY	2
	2	38.5	J-Field	990E203	1999	APR	14
	3	30.5	J-Field	1205	2000	JUN	1
	4	16.7	Rumsey Mansion	9903002	1999	SEP	25
	5	16.6	Eastern Shore	2901	2000	AUG	2
	6	16.2	J-Field	1005	2000	JUN	1
	7	16.0	J-Field	705	2000	JUN	1
	8	13.3	Cluster 3	9903103	1999	OCT	13
	9	11.9	Churchville	990CV601	1999	JUN	24
	10	11.7	J-Field	205	2000	JUN	1
Tetrachloroethene	1	8619.6	J-Field		1997	SEP	15
	2	8511.4	O-Field		1996	SEP	2
	3	3326.2	O-Field		1996	SEP	2
	4	3180.3	O-Field		1996	SEP	2
	5	2812.7	Jim Zinc's		1996	SEP	2
	6	2526.6	D-Field		1998	SEP	30
	7	1455.7	G-Street		1996	AUG	23
	8	1250.4	Churchville		1997	AUG	24
	9	1129.7	David Simmon's		1996	SEP	2
	10	1104.6	Eastern Shore	2901	2000	AUG	2
Dibromochloromethane	1	35.1	Eastern Shore	2901	2000	AUG	2
	2	29.2	J-Field	4901	2000	AUG	1
	3	26.4	J-Field	1006	2000	SEP	13
	4	22.4	Churchville	990CV301	1999	JUN	24
	5	20.4	Eastern Shore	4001	2000	AUG	2
	6	17.4	Eastern Shore	4301	2000	MAY	2
	7	15.6	J-Field	990F305	1999	AUG	6
	8	14.1	Cluster 3	Estuary	2000	AUG	3
	9	14.0	Cluster 3	4601	2000	AUG	3
	10	11.9	J-Field	106	2000	SEP	13
1,2-Dibromoethane	1	27.4	J-Field	805	2000	JUN	1
	2	17.1	J-Field	1006	2000	SEP	13
	3	16.5	Eastern Shore	2901	2000	AUG	2
	4	13.4	J-Field	990D105	1999	OCT	16
	5	11.0	Rumsey Mansion	9903002	1999	SEP	25
	6	8.8	J-Field	990E203	1999	APR	14
	7	8.1	J-Field	990D103	1999	APR	13
	8	7.7	Otter Creek	9903902	1999	SEP	25
	9	7.0	J-Field	1106	2000	SEP	13
	10	6.3	J-Field	990C105	1999	OCT	16
Chlorobenzene	1	1755.7	Eastern Shore	2901	2000	AUG	2
	2	1643.9	J-Field	990F106	1999	SEP	10
	3	555.0	Eastern Shore	4301	2000	MAY	2
	4	367.8	J-Field	990F306	1999	SEP	10

	5	219.9	Eastern Shore	4001	2000	AUG	2
	6	198.1	Eastern Shore	3601	2000	AUG	2
	7	180.3	J-Field	3502	2000	SEP	28
	8	177.0	Cluster 3	Estuary	2000	AUG	3
	9	163.7	J-Field	3501	2000	AUG	1
	10	153.8	J-Field	3401	2000	AUG	1
1,1,1,2-Tetrachloroethane	1	557.0	J-Field	990F106	1999	SEP	10
	2	49.2	Tower Hill	9907101	1999	JUL	26
	3	29.2	J-Field	C1#2	1999	MAR	11
	4	10.6	Eastern Shore	2901	2000	AUG	2
	5	10.1	J-Field	990D300	1999	MAR	11
	6	8.2	Silver Lake	9904602	1999	SEP	25
	7	5.8	J-Field	990D203	1999	APR	13
	8	5.6	Otter Creek	9903902	1999	SEP	25
	9	5.4	J-Field	990A104	1999	APR	27
	10	5.3	J-Field	3401	2000	AUG	1
Ethylbenzene	1	23608.7	O-Field		1998	SEP	29
	2	22432.9	J-Field	1106	2000	SEP	13
	3	11105.8	J-Field	1006	2000	SEP	13
	4	9971.5	Cluster 13	9902901	1999	JUL	23
	5	8569.6	O-Field		1998	SEP	29
	6	6925.2	Silver Lake	9904601	1999	JUL	27
	7	6756.8	J-Field	3502	2000	SEP	28
	8	6595.5	Tower Hill	9907102	1999	SEP	24
	9	6462.4	J-Field		1998	AUG	29
	10	6121.2	J-Field		1998	AUG	29
m,p-Xylenes	1	14959.0	Eastern Shore	2901	2000	AUG	2
	2	12675.4	J-Field	1106	2000	SEP	13
	3	11399.4	J-Field	1006	2000	SEP	13
	4	10545.1	Cluster 3	Estuary	2000	AUG	3
	5	9190.2	J-Field	3401	2000	AUG	1
	6	8863.6	Cluster 3	4801	2000	AUG	3
	7	8284.4	J-Field	406	2000	SEP	13
	8	8017.3	J-Field	3502	2000	SEP	28
	9	7747.7	J-Field	C2#2	1999	MAR	11
	10	6863.5	Eastern Shore	4301	2000	MAY	2
o-Xylene	1	60084.9	Cluster 13	9902902	1999	SEP	14
	2	14223.5	J-Field	990F606	1999	SEP	10
	3	13875.9	Youth Center	9902802	1999	SEP	14
	4	7051.6	Eastern Shore	2901	2000	AUG	2
	5	6541.6	Cluster 3	9904702	1999	SEP	14
	6	4928.7	J-Field	1106	2000	SEP	13
	7	4092.0	Cluster 3	Estuary	2000	AUG	3
	8	4068.3	J-Field	3502	2000	SEP	28
	9	3976.3	J-Field	3401	2000	AUG	1
	10	3373.0	Cluster 3	4801	2000	AUG	3
Styrene	1	1152236.6	J-Field	3401	2000	AUG	1
	2	1042170.8	Eastern Shore	2901	2000	AUG	2
	3	285257.7	J-Field	1106	2000	SEP	13
	4	241423.1	Eastern Shore	3601	2000	AUG	2
	5	229474.0	J-Field	1006	2000	SEP	13

	6	204550.4	J-Field	3501	2000	AUG	1
	7	184727.6	Eastern Shore	4001	2000	AUG	2
	8	172033.1	J-Field	4901	2000	AUG	1
	9	169822.0	J-Field	4101	2000	AUG	1
	10	152020.2	J-Field	606	2000	SEP	13
Isopropylbenzene	1	205837.2	J-Field	3401	2000	AUG	1
	2	69269.2	J-Field	1506	2000	SEP	13
	3	61109.8	Eastern Shore	2901	2000	AUG	2
	4	30729.3	Cluster 3	4801	2000	AUG	3
	5	29816.7	J-Field	990F701	1999	JUN	19
	6	28491.1	J-Field	4901	2000	AUG	1
	7	27423.3	Eastern Shore	4001	2000	AUG	2
	8	27345.9	Churchville	990CV601	1999	JUN	24
	9	22138.4	Churchville	990CV401	1999	JUN	24
	10	21374.5	Churchville	990CV301	1999	JUN	24
Tribromomethane	1	958.6	J-Field	990F106	1999	SEP	10
	2	64.6	Eastern Shore	2901	2000	AUG	2
	3	18.7	J-Field	3401	2000	AUG	1
	4	16.9	J-Field	990F101	1999	JUN	19
	5	14.6	J-Field	990A104	1999	APR	27
	6	12.3	J-Field	C1#2	1999	MAR	11
	7	11.8	J-Field	990D103	1999	APR	13
	8	10.2	Rumsey Mansion	9903002	1999	SEP	25
	9	10.1	J-Field	205	2000	JUN	1
	10	8.1	Cylburn Arboretum	9904202	1999	SEP	25
1,1,2,2-Tetrachloroethane	1	6933.8	J-Field	3401	2000	AUG	1
	2	4959.4	J-Field	990F106	1999	SEP	10
	3	4891.5	J-Field	990F306	1999	SEP	10
	4	2386.3	J-Field	990A304	1999	APR	27
	5	655.5	J-Field	990E304	1999	APR	27
	6	470.9	J-Field	990A104	1999	APR	27
	7	329.5	J-Field	990A305	1999	OCT	16
	8	303.5	J-Field	990B304	1999	JUN	19
	9	276.6	J-Field	603	2000	MAY	3
	10	243.6	J-Field	990F101	1999	JUN	19
1-Bromo-4-fluorobenzene	1	86300.6	J-Field	990E203	1999	APR	13
	2	42254.6	J-Field	3401	2000	AUG	1
	3	37108.3	Churchville	990CV401	1999	JUN	24
	4	31161.2	Eastern Shore	2901	2000	AUG	2
	5	23053.3	J-Field	990F201	1999	JUN	19
	6	18091.4	J-Field	1006	2000	SEP	13
	7	17869.8	J-Field	990F401	1999	JUN	19
	8	16723.8	Cluster 13	9902902	1999	SEP	14
	9	16448.7	Churchville	990CV601	1999	JUN	24
	10	14413.8	Eastern Shore	4301	2000	MAY	2
n-Propylbenzene	1	3118.0	Cluster 13	9902902	1999	SEP	14
	2	1198.7	J-Field	990F306	1999	SEP	10
	3	1026.8	Jones Farm	9903202	1999	SEP	14
	4	910.0	J-Field	990F106	1999	SEP	10
	5	683.7	Cluster 3	Estuary	2000	AUG	3
	6	645.0	J-Field	204	2000	MAY	14

	7	632.3	J-Field	803	2000	MAY	3
	8	623.2	Youth Center	9902802	1999	SEP	14
	9	558.1	J-Field	801	2000	APR	6
	10	505.6	J-Field	3503	2000	OCT	3
Bromobenzene	1	2869.7	J-Field	990F306	1999	SEP	10
	2	1297.2	J-Field	990F106	1999	SEP	10
	3	1150.1	Cluster 3	9904202	1999	SEP	14
	4	1142.4	J-Field	204	2000	MAY	14
	5	985.5	J-Field	990F606	1999	SEP	10
	6	887.0	Cluster 3	9904602	1999	SEP	14
	7	765.6	J-Field	801	2000	APR	6
	8	742.8	J-Field	3503	2000	OCT	3
	9	698.8	Cluster 3	9904702	1999	SEP	14
	10	648.5	Cluster 3	9902702	1999	SEP	14
1,3,5-Trimethylbenzene	1	12290.5	Tower Hill	9907102	1999	SEP	24
	2	7095.5	Churchville	990CV401	1999	JUN	24
	3	6016.0	J-Field	204	2000	MAY	14
	4	5580.4	Cluster 3	9904202	1999	SEP	14
	5	5171.7	J-Field	801	2000	APR	6
	6	4349.1	Tower Hill	9904002	1999	SEP	24
	7	2532.7	Jones Farm	9903202	1999	SEP	14
	8	1905.5	J-Field	990D205	1999	OCT	16
	9	1787.2	J-Field	704	2000	MAY	17
	10	1604.4	Cluster 3	4801	2000	AUG	3
2-Chlorotoluene	1	1193.3471	J-Field	990F306	1999	SEP	10
	2	688.767	J-Field	990F106	1999	SEP	10
	3	98.9409	J-Field	990E203	1999	APR	14
	4	30.7444	J-Field	C1#2	1999	MAR	11
	5	20.749	Eastern Shore	4301	2000	MAY	2
	6	15.784	Tower Hill	9904002	1999	SEP	24
	7	15.6335	Eastern Shore	2901	2000	AUG	2
	8	14.4898	J-Field	990E105	1999	OCT	16
	9	14.1224	J-Field	406	2000	SEP	13
	10	14.1006	J-Field	105	2000	JUN	1
4-Chlorotoluene	1	2815.1	J-Field	990F106	1999	SEP	10
	2	1180.2	J-Field	990F306	1999	SEP	10
	3	68.0	J-Field	990E203	1999	APR	14
	4	41.3	J-Field	C1#2	1999	MAR	11
	5	19.3	J-Field	1006	2000	SEP	13
	6	15.5	Tower Hill	9904002	1999	SEP	24
	7	15.4	Eastern Shore	2901	2000	AUG	2
	8	14.5	J-Field	990E105	1999	OCT	16
	9	14.1	J-Field	105	2000	JUN	1
	10	12.6	J-Field	990F205	1999	AUG	6
tert-Butylbenzene	1	10423.4	J-Field	3501	2000	AUG	1
	2	5072.1	Churchville	990CV401	1999	JUN	24
	3	1606.5	Jones Farm	9906901	1999	JUL	27
	4	1296.4	J-Field	990F205	1999	AUG	6
	5	1120.9	Tower Hill	9907102	1999	SEP	24
	6	716.2	J-Field	204	2000	MAY	14
	7	702.3	J-Field	4901	2000	AUG	1
	8	652.4	J-Field	990F106	1999	SEP	10

	9	640.7	Tower Hill	9904001	1999	JUL	27
	10	567.1	J-Field	801	2000	APR	6
1,2,4-Trimethylbenzene	1	5057.1	J-Field	204	2000	MAY	14
	2	4625.0	J-Field	3501	2000	AUG	1
	3	3977.9	J-Field	801	2000	APR	6
	4	1745.0	Churchville	990CV401	1999	JUN	24
	5	1328.5	Eastern Shore	3601	2000	AUG	2
	6	1249.9	J-Field	1304	2000	MAY	17
	7	1174.4	J-Field	1106	2000	SEP	13
	8	939.1	J-Field	3503	2000	OCT	3
	9	853.2	J-Field	990F306	1999	SEP	10
	10	679.7	Cluster 3	9904801	1999	AUG	17
Benezaldehyde	1	1601844.0	J-Field	1006	2000	SEP	13
	2	437803.4	Eastern Shore	2901	2000	AUG	2
	3	297576.0	J-Field	3501	2000	AUG	1
	4	208626.4	J-Field	3401	2000	AUG	1
	5	165841.6	J-Field	206	2000	SEP	13
	6	146802.3	J-Field	1106	2000	SEP	13
	7	129897.7	Eastern Shore	3601	2000	AUG	2
	8	128547.9	Eastern Shore	2801	2000	AUG	20
	9	123840.4	J-Field	1506	2000	SEP	13
	10	103174.2	Eastern Shore	4301	2000	MAY	2
sec-Butylbenzene	1	61007.9	J-Field	1006	2000	SEP	13
	2	16606.2	Eastern Shore	2901	2000	AUG	2
	3	6237.9	J-Field	206	2000	SEP	13
	4	4838.7	Eastern Shore	2801	2000	AUG	20
	5	4804.5	Tower Hill	9907101	1999	JUL	26
	6	4281.1	J-Field	3503	2000	OCT	3
	7	3766.5	Eastern Shore	4301	2000	MAY	2
	8	3513.4	Otter Creek	9903902	1999	SEP	25
	9	3508.8	J-Field	990F205	1999	AUG	6
	10	3261.1	Tower Hill	9904001	1999	JUL	27
Isopropyltoluene	1	17997.4	J-Field	3401	2000	AUG	1
	2	17700.5	J-Field	805	2000	JUN	1
	3	10666.0	J-Field	905	2000	JUN	1
	4	10543.7	Churchville	990CV401	1999	JUN	24
	5	7150.4	Cluster 3	4801	2000	AUG	3
	6	6230.0	J-Field	4901	2000	AUG	1
	7	4870.8	Tower Hill	9907102	1999	SEP	24
	8	3925.1	J-Field	3501	2000	AUG	1
	9	3081.4	Eastern Shore	3601	2000	AUG	2
	10	2420.4	Tower Hill	9904001	1999	JUL	27
1,3-Dichlorobenzene	1	3363.2	J-Field	204	2000	MAY	14
	2	1653.5	J-Field	990F306	1999	SEP	10
	3	1535.0	J-Field	990F106	1999	SEP	10
	4	925.4	J-Field	803	2000	MAY	3
	5	802.1	J-Field	1006	2000	SEP	13
	6	729.3	J-Field	1304	2000	MAY	17
	7	549.8	J-Field	3503	2000	OCT	3
	8	511.7	J-Field	1004	2000	MAY	17
	9	369.7	J-Field	990F205	1999	AUG	6
	10	340.9	J-Field	801	2000	APR	6

1,4-Dichlorobenzene	1	3248.9	J-Field	204	2000	MAY	14
	2	2395.3	J-Field	990F306	1999	SEP	10
	3	1416.3	J-Field	990F106	1999	SEP	10
	4	893.1	J-Field	803	2000	MAY	3
	5	703.7	J-Field	1304	2000	MAY	17
	6	579.1	J-Field	1006	2000	SEP	13
	7	548.4	Bush River		1997	AUG	19
	8	520.8	J-Field	3503	2000	OCT	3
	9	494.3	J-Field	1004	2000	MAY	17
	10	400.8	D-Field		1998	AUG	12
n-Butylbenzene	1	2443.5	J-Field	1006	2000	SEP	13
	2	1361.5	J-Field	990F306	1999	SEP	10
	3	781.8	J-Field	990F106	1999	SEP	10
	4	558.7	J-Field	206	2000	SEP	13
	5	446.5	J-Field	204	2000	MAY	14
	6	311.0	J-Field	801	2000	APR	6
	7	226.1	J-Field	990F201	1999	JUN	19
	8	201.9	Tower Hill	9907101	1999	JUL	26
	9	155.3	J-Field	606	2000	SEP	13
	10	126.4	J-Field	990E203	1999	APR	14
1,2-4-Dichlorobenzene	1	31141.7	J-Field	990E203	1999	APR	13
	2	27461.5	J-Field	3401	2000	AUG	1
	3	24651.5	Eastern Shore	2901	2000	AUG	2
	4	17981.5	J-Field	1006	2000	SEP	13
	5	11325.6	Eastern Shore	4301	2000	MAY	2
	6	10813.0	J-Field	1106	2000	SEP	13
	7	9242.0	Cluster 3	4601	2000	AUG	3
	8	8077.1	Cluster 3	9903703	1999	OCT	13
	9	8039.2	Eastern Shore	4001	2000	AUG	2
	10	7893.0	J-Field	990F401	1999	JUN	19
1,2-Dichlorobenzene	1	6960.2	J-Field	990F106	1999	SEP	10
	2	1548.3	J-Field	990F306	1999	SEP	10
	3	89.4	J-Field	990E203	1999	APR	14
	4	69.0	J-Field	C1#2	1999	MAR	11
	5	63.4	J-Field	990F101	1999	JUN	19
	6	48.5	J-Field	990E105	1999	OCT	16
	7	41.0	Cluster 3	9902703	1999	OCT	13
	8	26.4	Rumsey Mansion	9903002	1999	SEP	25
	9	19.4	J-Field	803	2000	MAY	3
	10	18.9	J-Field	990C105	1999	OCT	16
Hexachloroethane	1	64397.5	J-Field	3401	2000	AUG	1
	2	17704.3	J-Field	4901	2000	AUG	1
	3	10922.8	J-Field	1506	2000	SEP	13
	4	9256.9	Cluster 3	4801	2000	AUG	3
	5	8044.8	J-Field	3501	2000	AUG	1
	6	6846.7	J-Field	1106	2000	SEP	13
	7	6730.7	Eastern Shore	4402	2000	SEP	27
	8	6525.8	Eastern Shore	3601	2000	AUG	2
	9	5648.5	Eastern Shore	4001	2000	AUG	2
	10	2271.3	J-Field	990F101	1999	JUN	19
Acetophenone	1	9409.5	J-Field	990F306	1999	SEP	10
	2	6038.1	J-Field	990F106	1999	SEP	10

	3	5594.1	O-Field		1996	SEP	2
	4	3619.0	Laudrick Creek		1996	SEP	20
	5	3128.9	J-Field	990F406	1999	SEP	10
	6	2862.1	D-Field		1998	AUG	9
	7	2813.9	J-Field	204	2000	MAY	14
	8	1814.3	J-Field		1998	JUN	27
	9	1674.8	EBranch Canal Creek		1996	AUG	23
	10	1570.8	O-Field		1996	SEP	21
1,2-Dibromo-3-chloropropane	1	3956.1	J-Field	990F106	1999	SEP	10
	2	2124.6	J-Field	990F306	1999	SEP	10
	3	235.0	J-Field	990F101	1999	JUN	19
	4	178.8	J-Field	C1#2	1999	MAR	11
	5	85.9	Cluster 3	9902703	1999	OCT	13
	6	71.3	Rumsey Mansion	9903002	1999	SEP	25
	7	65.0	J-Field	990D105	1999	OCT	16
	8	35.6	J-Field	105	2000	JUN	1
	9	24.7	Churchville	9903803	1999	SEP	24
	10	24.4	J-Field	990E203	1999	APR	14
1,2,4-Trichlorobenzene	1	5041.1	J-Field	990F306	1999	SEP	10
	2	2522.7	J-Field	990F106	1999	SEP	10
	3	336.2	J-Field	990F406	1999	SEP	10
	4	156.4	J-Field	C1#2	1999	MAR	11
	5	113.6	J-Field	990F101	1999	JUN	19
	6	85.4	Rumsey Mansion	9903002	1999	SEP	25
	7	83.8	J-Field	990D105	1999	OCT	16
	8	67.0	J-Field	990E203	1999	APR	14
	9	29.9	J-Field	105	2000	JUN	1
	10	27.5	Cluster 3	9902703	1999	OCT	13
Naphthalene	1	21682.5	Churchville		1998	OCT	27
	2	20986.6	J-Field	990F306	1999	SEP	10
	3	19477.5	Churchville		1998	OCT	27
	4	11455.5	J-Field	990F106	1999	SEP	10
	5	2257.5	Churchville		1998	OCT	27
	6	2211.8	J-Field	204	2000	MAY	14
	7	1622.4	Carrol Island		1998	JUN	18
	8	1575.0	Churchville		1998	OCT	27
	9	1327.8	Churchville		1996	AUG	25
	10	1288.5	J-Field	801	2000	APR	6
1,2,3-Trichlorobenzene	1	8049.7	J-Field	990F106	1999	SEP	10
	2	7624.0	J-Field	990F306	1999	SEP	10
	3	315.0	J-Field	990F101	1999	JUN	19
	4	242.0	J-Field	C1#2	1999	MAR	11
	5	177.1	Cluster 3	9902703	1999	OCT	13
	6	102.8	J-Field	990D105	1999	OCT	16
	7	95.1	J-Field	990E203	1999	APR	14
	8	71.8	J-Field	990F606	1999	SEP	10
	9	69.2	Rumsey Mansion	9903002	1999	SEP	25
	10	53.5	J-Field	990E105	1999	OCT	16

TABLE 8.9.3 Ten Highest Concentrations for Trace Elements and Heavy Metals in Forager Bees (ppm)
(ranked from highest to lowest, 1-10, Respectively)

	Rank	Conc	Location	Sample ID	Year	Month	Day
Arsenic	1	0.3	Bush River	970015	1997	AUG	25
	2	0.2	Bush River	970008	1997	AUG	25
	3	0.2	Bush River	970009	1997	AUG	26
	4	0.2	Bush River	970005	1997	AUG	25
	5	0.2	Bush River	970013	1997	AUG	25
	6	0.2	Bush River	970017	1997	JUN	26
	7	0.2	Bush River	970016	1997	JUN	26
	8	0.2	Bush River	970006	1997	AUG	26
	9	0.2	Bush River	970007	1997	AUG	26
	10	0.2	Bush River	970011	1997	JUN	26
Barium	1	9.9	Bush River	970017	1997	JUN	26
	2	9.2	Bush River	970010	1997	JUN	26
	3	9.0	Bush River	970014	1997	JUN	26
	4	5.7	Bush River	970013	1997	AUG	25
	5	5.6	Bush River	970012	1997	JUN	26
	6	5.4	Bush River	970009	1997	AUG	26
	7	5.3	Bush River	970011	1997	JUN	26
	8	5.1	Bush River	970008	1997	AUG	25
	9	3.6	Bush River	970005	1997	AUG	25
	10	2.4	Bush River	970015	1997	AUG	25
Beryllium	1	0.2	Bush River	970032	1997	AUG	26
	2	0.1	Bush River	970005	1997	AUG	25
	3	1	J-Field	992052	1998	JUL	21
	4	0.8	Otter Creek	992115	1998	JUL	17
	5	0.7	Lorh's Orchard	9917401	1999	OCT	18
	6	0.5	J-Field	993C102	1999	NOV	2
	7	0.4	Jones Farm	9936901	1999	OCT	8
	8	0.3	J-Field	992076	1998	OCT	2
	9	0.3	O-Field	96-0866	1996	AUG	26
	10	0.3	Lorh's Orchard	9937401	1999	OCT	6
Bismuth	1	12.9	Silver Lake	992133	1998	JUL	30
	2	0.2	Otter Creek	992115	1998	JUL	17
	3	0.2	O-Field	96-0866	1996	AUG	26
	4	0.1	Lorh's Orchard	9917401	1999	OCT	18
	5	0	Bush River	970032	1997	AUG	26
	6	0	Bush River	970005	1997	AUG	25
	7	0	J-Field	992052	1998	JUL	21
	8	0	J-Field	993C102	1999	NOV	2
	9	0	Jones Farm	9936901	1999	OCT	8
	10	0	J-Field	992076	1998	OCT	2
Cadmium	1	0.3	Bush River	970005	1997	AUG	25
	2	0.3	Bush River	970009	1997	AUG	26
	3	0.3	Bush River	970015	1997	AUG	25
	4	0.3	Bush River	970006	1997	AUG	26
	5	0.2	Bush River	970008	1997	AUG	25
	6	0.2	Bush River	970007	1997	AUG	26
	7	0.1	Bush River	970017	1997	JUN	26

	8	0.1	Bush River	970010	1997	JUN	26
	9	0.1	Bush River	970014	1997	JUN	26
	10	0.1	Bush River	970016	1997	JUN	26
Cobalt	1	0.5	Bush River	970009	1997	AUG	26
	2	0.5	Bush River	970017	1997	JUN	26
	3	0.5	Bush River	970010	1997	JUN	26
	4	0.5	Bush River	970014	1997	JUN	26
	5	0.5	Bush River	970016	1997	JUN	26
	6	0.4	Bush River	970005	1997	AUG	25
	7	0.4	Bush River	970012	1997	JUN	26
	8	0.4	Bush River	970011	1997	JUN	26
	9	0.3	Bush River	970015	1997	AUG	25
	10	0.3	Bush River	970006	1997	AUG	26
Chromium	1	0.4	Bush River	970009	1997	AUG	26
	2	0.4	Bush River	970017	1997	JUN	26
	3	0.4	Bush River	970010	1997	JUN	26
	4	0.4	Bush River	970014	1997	JUN	26
	5	0.4	Bush River	970016	1997	JUN	26
	6	0.4	Bush River	970012	1997	JUN	26
	7	0.4	Bush River	970011	1997	JUN	26
	8	0.3	Bush River	970005	1997	AUG	25
	9	0.3	Bush River	970015	1997	AUG	25
	10	0.3	Bush River	970006	1997	AUG	26
Cesium	1	0.2	Lorh's Orchard	9917401	1999	OCT	18
	2	0.2	Otter Creek	992115	1998	JUL	17
	3	0.2	O-Field	96-0866	1996	AUG	26
	4	0.2	Canal Creek	96-1279	1996	SEP	29
	5	0.1	Canal Creek	96-0870	1996	AUG	26
	6	0.1	WBranch Canal Creek	970047	1997	AUG	19
	7	0.1	J-Field	992052	1998	JUL	21
	8	0	Bush River	970009	1997	AUG	26
	9	0	Bush River	970017	1997	JUN	26
	10	0	Bush River	970010	1997	JUN	26
Copper	1	33.9	Bush River	970017	1997	JUN	26
	2	25.4	Bush River	970016	1997	JUN	26
	3	22.9	Bush River	970011	1997	JUN	26
	4	22.3	Bush River	970012	1997	JUN	26
	5	21.5	Bush River	970008	1997	AUG	25
	6	19.3	Bush River	970014	1997	JUN	26
	7	18.3	Bush River	970013	1997	AUG	25
	8	17.4	Bush River	970010	1997	JUN	26
	9	15.6	Bush River	970015	1997	AUG	25
	10	15.5	Bush River	970006	1997	AUG	26
Gallium	1	1.1	Bush River	970016	1997	JUN	26
	2	0.7	Bush River	970017	1997	JUN	26
	3	0.7	Bush River	970010	1997	JUN	26
	4	0.6	Bush River	970014	1997	JUN	26
	5	0.4	Bush River	970011	1997	JUN	26
	6	0.4	Bush River	970012	1997	JUN	26
	7	0.4	Bush River	970013	1997	AUG	25
	8	0.4	Bush River	970009	1997	AUG	26
	9	0.3	Bush River	970008	1997	AUG	25

	10	0.3	Bush River	970005	1997	AUG	25
Manganese	1	532	Bush River	970016	1997	JUN	26
	2	500	Bush River	970017	1997	JUN	26
	3	414	Bush River	970010	1997	JUN	26
	4	408	Bush River	970014	1997	JUN	26
	5	330	Bush River	970012	1997	JUN	26
	6	323	Bush River	970011	1997	JUN	26
	7	250	Bush River	970009	1997	AUG	26
	8	244	Bush River	970005	1997	AUG	25
	9	219	Bush River	970008	1997	AUG	25
	10	163	Bush River	970013	1997	AUG	25
Nickel	1	1.6	Bush River	970009	1997	AUG	26
	2	1.5	Bush River	970007	1997	AUG	26
	3	0.8	Bush River	970005	1997	AUG	25
	4	0.7	Bush River	970006	1997	AUG	26
	5	0.6	Bush River	970011	1997	JUN	26
	6	0.5	Bush River	970010	1997	JUN	26
	7	0.4	Bush River	970016	1997	JUN	26
	8	0.4	Bush River	970014	1997	JUN	26
	9	0.4	Bush River	970012	1997	JUN	26
	10	0.4	Bush River	970008	1997	AUG	25
Lead	1	7.2	Bush River	970008	1997	AUG	25
	2	6.8	Bush River	970007	1997	AUG	26
	3	6.7	Bush River	970012	1997	JUN	26
	4	6.2	Bush River	970009	1997	AUG	26
	5	5.8	Bush River	970015	1997	AUG	25
	6	5.5	Bush River	970011	1997	JUN	26
	7	5.0	Bush River	970005	1997	AUG	25
	8	4.9	Bush River	970010	1997	JUN	26
	9	4.7	Bush River	970016	1997	JUN	26
	10	4.5	Bush River	970006	1997	AUG	26
Rubidium	1	9.5	Bush River	970010	1997	JUN	26
	2	6.5	Bush River	970009	1997	AUG	26
	3	6.5	Bush River	970015	1997	AUG	25
	4	6.3	Bush River	970008	1997	AUG	25
	5	6.1	Bush River	970006	1997	AUG	26
	6	5.3	Bush River	970005	1997	AUG	25
	7	4.5	Bush River	970007	1997	AUG	26
	8	4.0	Bush River	970013	1997	AUG	25
	9	20.4	Bush River	970016	1997	JUN	26
	10	14.2	Bush River	970011	1997	JUN	26
Selenium	1	0.3	Bush River	970010	1997	JUN	26
	2	0.3	Bush River	970009	1997	AUG	26
	3	0.3	Bush River	970015	1997	AUG	25
	4	0.3	Bush River	970013	1997	AUG	25
	5	0.3	Bush River	970016	1997	JUN	26
	6	0.3	Bush River	970011	1997	JUN	26
	7	0.3	Bush River	970017	1997	JUN	26
	8	0.3	Bush River	970014	1997	JUN	26
	9	0.2	Bush River	970006	1997	AUG	26
	10	0.2	Bush River	970005	1997	AUG	25
Strontium	1	8.0	Bush River	970008	1997	AUG	25

	2	6.9	Bush River	970016	1997	JUN	26
	3	6.5	Bush River	970005	1997	AUG	25
	4	5.9	Bush River	970006	1997	AUG	26
	5	5.2	Bush River	970015	1997	AUG	25
	6	5.0	Bush River	970009	1997	AUG	26
	7	5.0	Bush River	970013	1997	AUG	25
	8	4.8	Bush River	970007	1997	AUG	26
	9	4.1	Bush River	970017	1997	JUN	26
	10	3.8	Bush River	970010	1997	JUN	26
Titanium	1	9	Otter Creek	9937901	1999	OCT	6
	2	2.2	Silver Lake	992133	1998	JUL	30
	3	0.7	Otter Creek	992115	1998	JUL	17
	4	0.7	Lorh's Orchard	9917401	1999	OCT	18
	5	0.4	J-Field	993C102	1999	NOV	2
	6	0.4	Jones Farm	9916901	1999	OCT	16
	7	0.3	Conowingo Orchard	9913701	1999	OCT	18
	8	0.3	Lorh's Orchard	9937401	1999	OCT	6
	9	0.2	J-Field	992078	1998	JUL	25
	10	0.2	O-Field	96-0866	1996	AUG	26
Uranium	1	9.6	J-Field	993B302	1999	NOV	2
	2	0.2	Otter Creek	992115	1998	JUL	17
	3	0.2	O-Field	96-0866	1996	AUG	26
	4	0.1	Lorh's Orchard	9917401	1999	OCT	18
	5	0	Otter Creek	9937901	1999	OCT	6
	6	0	Silver Lake	992133	1998	JUL	30
	7	0	J-Field	993C102	1999	NOV	2
	8	0	Jones Farm	9916901	1999	OCT	16
	9	0	Conowingo Orchard	9913701	1999	OCT	18
	10	0	Lorh's Orchard	9937401	1999	OCT	6
Vanadium	1	1.8	WBranch Canal Creek	970049d	1997	AUG	19
	2	1.8	WBranch Canal Creek	970043	1997	AUG	19
	3	1.5	Lorh's Orchard	9917401	1999	OCT	18
	4	1.3	Otter Creek	992115	1998	JUL	17
	5	1.1	J-Field	993C102	1999	NOV	2
	6	1.1	J-Field	992099	1998	JUL	25
	7	1.1	Burrcomb	992108	1998	JUL	29
	8	1.1	Youth Center	992110	1998	SEP	25
	9	1	J-Field	992066	1998	JUL	25
	10	1	WBranch Canal Creek	970047	1997	AUG	19
Zinc	1	77.3	Bush River	970008	1997	AUG	25
	2	77.1	Bush River	970009	1997	AUG	26
	3	73.5	Bush River	970005	1997	AUG	25
	4	69.9	Bush River	970013	1997	AUG	25
	5	69.6	Bush River	970015	1997	AUG	25
	6	69.3	Bush River	970017	1997	JUN	26
	7	62.8	Bush River	970016	1997	JUN	26
	8	59.2	Bush River	970006	1997	AUG	26
	9	57.8	Bush River	970007	1997	AUG	26
	10	48.5	Bush River	970011	1997	JUN	26

TABLE 8.9.4 Ten Highest Concentrations for Trace Elements and Heavy Metals in Dead Bees (ppm)
(ranked from highest to lowest, 1-10, Respectively)

	Rank	Conc	Location	Sample ID	Year	Month	Day
Arsenic	1	2.5	J-Field	992093	1998	JUL	6
	2	2.1	O-Field	995042	1998	JUN	27
	3	2	J-Field	992082	1998	MAY	26
	4	1	J-Field	992098	1998	MAY	26
	5	0.9	Canal Creek	96-1262	1996	SEP	29
	6	0.8	Cluster 3	9964202	1999	AUG	23
	7	0.7	Canal Creek	96-1259	1996	SEP	29
	8	0.7	Canal Creek	96-1260	1996	SEP	29
	9	0.7	O-Field	992050	1998	JUL	6
	10	0.7	O-Field	96-1263	1996	SEP	29
Barium	1	88.6	J-Field	9963504	1999	SEP	8
	2	81.9	J-Field	9965001	1999	APR	8
	3	72	J-Field	9964904	1999	SEP	8
	4	63.5	J-Field	9963004	1999	SEP	8
	5	58.8	J-Field	9965004	1999	AUG	11
	6	55.6	J-Field	9963404	1999	SEP	8
	7	35.7	J-Field	9965004	1999	AUG	11
	8	30.4	J-Field	9963503	1999	JUL	30
	9	29.5	J-Field	9964104	1999	SEP	8
	10	26.9	J-Field	9963503	1999	JUL	30
Beryllium	1	1.8	O-Field	995042	1998	JUN	27
	2	0.8	J-Field	992093	1998	JUL	6
	3	0.3	O-Field	992051	1998	JUL	6
	4	0.2	Churchville	992107	1998	JUL	28
	5	0.2	J-Field	992083	1998	JUL	6
	6	0.2	O-Field	992050	1998	JUL	6
	7	0.2	J-Field	992077	1998	MAY	26
	8	0.1	Churchville	992106	1998	JUL	28
	9	0.1	O-Field	992032	1998	JUN	27
	10	0.1	D-Field	992063	1998	AUG	20
Bismuth	1	1.7	O-Field	995042	1998	JUN	27
	2	0.1	J-Field	992093	1998	JUL	6
	3	0.1	O-Field	992051	1998	JUL	6
	4	0.1	Churchville	992107	1998	JUL	28
	5	0	J-Field	992083	1998	JUL	6
	6	0	O-Field	992050	1998	JUL	6
	7	0	J-Field	992077	1998	MAY	26
	8	0	Churchville	992106	1998	JUL	28
	9	0	O-Field	992032	1998	JUN	27
	10	0	D-Field	992063	1998	AUG	20
Cadmium	1	1.8	O-Field	995042	1998	JUN	27
	2	1.3	J-Field	992093	1998	JUL	6
	3	0.6	J-Field	9963004	1999	SEP	8
	4	0.6	J-Field	992082	1998	MAY	26
	5	0.5	J-Field	992074	1998	OCT	2
	6	0.5	J-Field	992093	1998	JUL	6
	7	0.5	J-Field	992082	1998	MAY	26

	8	0.5	O-Field	96-1267	1996	SEP	29
	9	0.4	J-Field	992083	1998	JUL	6
	10	0.4	Cluster 13	9962902	1999	JUL	29
Cobalt	1	4.9	O-Field	992043	1998	JUL	21
	2	3.4	O-Field	995042	1998	JUN	27
	3	2	O-Field	992168	1998	JUL	18
	4	1.7	J-Field	9964103	1999	JUL	30
	5	1.4	J-Field	992093	1998	JUL	6
	6	1.1	Canal Creek	96-1259	1996	SEP	29
	7	1	O-Field	992036	1998	AUG	3
	8	1	O-Field	992036	1998	JUN	27
	9	0.9	Churchville	992106	1998	JUL	28
	10	0.8	Churchville	992107	1998	JUL	28
Chromium	1	2	O-Field	995042	1998	JUN	27
	2	1.7	O-Field	992034	1998	JUN	27
	3	1.1	J-Field	992093	1998	JUL	6
	4	1	J-Field	992073	1998	SEP	25
	5	0.9	Churchville	96-1276	1996	SEP	29
	6	0.8	Churchville	96-1270	1996	SEP	29
	7	0.8	O-Field	96-1268	1996	SEP	29
	8	0.8	O-Field	96-1267	1996	SEP	29
	9	0.7	Canal Creek	96-1259	1996	SEP	29
	10	0.7	Canal Creek	96-1262	1996	SEP	29
Cesium	1	1.7	O-Field	995042	1998	JUN	27
	2	0.3	J-Field	992093	1998	JUL	6
	3	0.2	J-Field	992082	1998	MAY	26
	4	0.1	Churchville	992107	1998	JUL	28
	5	0.1	O-Field	992051	1998	JUL	6
	6	0	O-Field	992034	1998	JUN	27
	7	0	J-Field	992073	1998	SEP	25
	8	0	Churchville	96-1276	1996	SEP	29
	9	0	Churchville	96-1270	1996	SEP	29
	10	0	O-Field	96-1268	1996	SEP	29
Copper	1	37.7	J-Field	CONDO6	1999	JUL	6
	2	36.5	J-Field	992071	1998	JUL	6
	3	34.7	J-Field	Condo 7	1999	JUL	6
	4	34	J-Field	CONDO6	1999	JUN	18
	5	33.7	J-Field	992093	1998	JUL	6
	6	31.4	Canal Creek	96-1259	1996	SEP	29
	7	31.2	Canal Creek	96-1257	1996	SEP	29
	8	31.1	O-Field	992041	1998	MAY	19
	9	31	Canal Creek	96-1257d	1996	SEP	29
	10	30.5	Canal Creek	96-1262	1996	SEP	29
Gallium	1	5.3	J-Field	9963504	1999	SEP	8
	2	4.3	J-Field	9965001	1999	APR	8
	3	4.2	J-Field	9964904	1999	SEP	8
	4	3.7	J-Field	9963004	1999	SEP	8
	5	3.4	O-Field	995042	1998	JUN	27
	6	3.2	J-Field	9963404	1999	SEP	8
	7	3.1	J-Field	9965004	1999	AUG	11
	8	1.8	J-Field	9964104	1999	SEP	8
	9	1.8	J-Field	9965004	1999	AUG	11

	10	1.7	J-Field	9963503	1999	JUL	30
Manganese	1	621	J-Field	992093	1998	JUL	6
	2	602	J-Field	CONDO6	1999	JUN	18
	3	585	J-Field	992093	1998	JUL	6
	4	466	J-Field	992082	1998	MAY	26
	5	461	J-Field	CONDO6	1999	JUL	6
	6	459	J-Field	992082	1998	MAY	26
	7	456	J-Field	9965004	1999	AUG	11
	8	453	Churchville	9964002	1999	JUL	29
	9	403	Cluster 13	9962902	1999	JUL	29
	10	403	J-Field	992098	1998	MAY	26
Nickel	1	2.8	J-Field	992073	1998	SEP	25
	2	2.2	Churchville	9964302	1999	JUL	29
	3	2.1	J-Field	992098	1998	MAY	26
	4	2.1	J-Field	9963503	1999	JUL	30
	5	2.1	Churchville	992106	1998	JUL	28
	6	2.1	J-Field	992070	1998	MAY	26
	7	2.1	O-Field	995042	1998	JUN	27
	8	1.9	J-Field	992098	1998	MAY	26
	9	1.9	J-Field	992101	1998	OCT	2
	10	1.9	O-Field	992036	1998	AUG	3
Lead	1	6 .3	J-Field	992081	1998	OCT	2
	2	10.9	Churchville	992106	1998	JUL	28
	3	10.6	J-Field	992086	1998	SEP	25
	4	9.8	J-Field	992088	1998	MAY	26
	5	9.4	J-Field	992098	1998	MAY	26
	6	9.3	O-Field	992168	1998	JUL	18
	7	8.4	J-Field	992098	1998	MAY	26
	8	8.3	J-Field	992070	1998	MAY	26
	9	7.7	D-Field	992063	1998	AUG	20
	10	7.7	O-Field	992034	1998	JUN	27
Rubidium	1	29.8	O-Field	992036	1998	AUG	3
	2	27.8	O-Field	992036	1998	JUN	27
	3	24.6	D-Field	992063	1998	AUG	20
	4	23.8	O-Field	992033	1998	JUN	27
	5	23.6	J-Field	992077	1998	MAY	26
	6	23.2	O-Field	992038	1998	JUL	6
	7	21.5	O-Field	992051	1998	JUL	6
	8	20.8	J-Field	992070	1998	MAY	26
	9	20.6	O-Field	992053	1998	AUG	31
	10	20.5	O-Field	992030	1998	JUN	27
Selenium	1	2.3	O-Field	995042	1998	JUN	27
	2	1.3	J-Field	992092	1998	MAY	26
	3	1.1	J-Field	992098	1998	MAY	26
	4	1.1	Cluster 3	9962702	1999	AUG	23
	5	1	J-Field	992093	1998	JUL	6
	6	1	Churchville	992107	1998	JUL	28
	7	1	Cluster 3	9963102	1999	AUG	23
	8	0.9	J-Field	992098	1998	MAY	26
	9	0.9	Churchville	992106	1998	JUL	28
	10	0.8	J-Field	992070	1998	MAY	26
Strontium	1	24.4	O-Field	995042	1998	JUN	27

	2	22.9	O-Field	992042	1998	JUN	27
	3	21.7	O-Field	992042	1998	JUN	27
	4	16.9	J-Field	9963503	1999	JUL	30
	5	16.4	J-Field	9963503	1999	JUL	30
	6	15.9	J-Field	9963404	1999	SEP	8
	7	15.5	J-Field	9963004	1999	SEP	8
	8	14.7	J-Field	9965004	1999	AUG	11
	9	14.1	J-Field	992093	1998	JUL	6
	10	12.8	J-Field	992093	1998	JUL	6
Titanium	1	1.7	O-Field	995042	1998	JUN	27
	2	0.7	J-Field	992093	1998	JUL	6
	3	0.3	O-Field	992051	1998	JUL	6
	4	0.2	O-Field	992050	1998	JUL	6
	5	0.2	J-Field	992077	1998	MAY	26
	6	0.1	J-Field	992083	1998	JUL	6
	7	0.1	O-Field	992032	1998	JUN	27
	8	0.1	Churchville	992107	1998	JUL	28
	9	0	O-Field	992042	1998	JUN	27
	10	0	O-Field	992042	1998	JUN	27
Uranium	1	1.7	O-Field	995042	1998	JUN	27
	2	0.1	O-Field	992051	1998	JUL	6
	3	0.1	Churchville	992107	1998	JUL	28
	4	0	J-Field	992093	1998	JUL	6
	5	0	O-Field	992050	1998	JUL	6
	6	0	J-Field	992077	1998	MAY	26
	7	0	J-Field	992083	1998	JUL	6
	8	0	O-Field	992032	1998	JUN	27
	9	0	O-Field	992042	1998	JUN	27
	10	0	O-Field	992042	1998	JUN	27
Vanadium	1	2.3	O-Field	995042	1998	JUN	27
	2	1.5	J-Field	992093	1998	JUL	6
	3	1.5	J-Field	992067	1998	AUG	25
	4	1.3	J-Field	992093	1998	JUL	6
	5	1.3	J-Field	992096	1998	JUL	6
	6	1.2	J-Field	992073	1998	SEP	25
	7	1.2	O-Field	96-1267	1996	SEP	29
	8	1.2	O-Field	96-1268	1996	SEP	29
	9	1.2	Churchville	96-1276	1996	SEP	29
	10	1.1	O-Field	992032	1998	JUN	27
Zinc	1	1030	D-Field	992063	1998	AUG	20
	2	542	O-Field	995042	1998	JUN	27
	3	346	O-Field	992042	1998	JUN	27
	4	332	O-Field	992042	1998	JUN	27
	5	210	J-Field	992090	1998	AUG	25
	6	197	J-Field	992073	1998	SEP	25
	7	177	O-Field	992029	1998	JUN	27
	8	176	J-Field	9963004	1999	SEP	8
	9	173	Cluster 3	9964601	1999	AUG	11
	10	165	O-Field	992053	1998	AUG	31

TABLE 8.9.5 Ten Highest Concentrations for Trace Elements and Heavy Metals in Pollen (ppm)
(ranked from highest to lowest, 1-10, Respectively)

	Rank	Conc	Location	Sample ID	Year	Month	Day
Arsenic	1	0.9	Rumsey Mansion	9974801	1999	OCT	6
	2	0.8	Cluster 3	9974201	1999	SEP	20
	3	0.7	Youth Center	9972801	1999	SEP	20
	4	0.6	O-Field	970051	1997	AUG	12
	5	0.6	Lorh's Orchard	9977401	1999	SEP	20
	6	0.6	Canal Creek	970113	1997	AUG	24
	7	0.6	J-Field	9973403	1999	SEP	13
	8	0.5	O-Field	970092	1997	JUL	21
	9	0.5	O-Field	970062	1997	AUG	12
	10	0.5	O-Field	970110	1997	JUL	29
Barium	1	47.9	O-Field	970117	1997	AUG	19
	2	37	O-Field	970068	1997	JUL	29
	3	32.8	O-Field	970094	1997	AUG	12
	4	31.6	Cluster 3	9974601	1999	SEP	20
	5	29.6	O-Field	970110	1997	JUL	29
	6	29.2	O-Field	970111	1997	JUL	29
	7	27.2	O-Field	970051	1997	AUG	12
	8	25.9	Canal Creek	970134	1997	JUL	21
	9	25.3	O-Field	970062	1997	AUG	12
	10	24.8	Canal Creek	970133	1997	JUL	21
Beryllium	1	0.2	Canal Creek	970113	1997	AUG	24
	2	0.2	Bush River	970085	1997	AUG	11
	3	0.1	O-Field	970097	1997	AUG	12
	4	9.5	Cluster 3	9974701	1999	SEP	20
	5	0.5	J-Field	9973403	1999	SEP	13
	6	0.1	Cluster 3	9972701	1999	SEP	20
	7	0.1	Canal Creek	970103	1997	AUG	4
	8	0.1	Lorh's Orchard	9977401	1999	SEP	20
	9	0.064	Eastern Shore	44	2000	OCT	16
	10	0.051	Cluster 3	48	2000	AUG	22
Bismuth	1	0.2	Canal Creek	970113	1997	AUG	24
	2	0.1	Bush River	970085	1997	AUG	11
	3	0.1	Canal Creek	970056	1997	JUL	21
	4	0.034	Eastern Shore	36	2000	SEP	23
	5	0.015	Cluster 3	48	2000	AUG	22
	6	0.009	J-Field	26	2000	AUG	28
	7	0.009	Eastern Shore	38	2000	AUG	23
	8	0.008	J-Field	34	2000	AUG	28
	9	0.007	Cluster 3	42	2000	AUG	22
	10	0.007	Cluster 3	31	2000	AUG	22
Cadmium	1	1.2	J-Field	JFA2	1999	JUN	5
	2	1.1	Otter Creek	9977901	1999	SEP	27
	3	0.6	J-Field	9973403	1999	SEP	13
	4	0.6	Otter Creek	9973901	1999	SEP	27
	5	0.5	Canal Creek	970069	1997	AUG	24
	6	0.5	Cylburn Arboretum	9974402	1999	OCT	8
	7	0.4	Canal Creek	970113	1997	AUG	24

	8	0.4	Canal Creek	970102	1997	AUG	24
	9	0.4	Canal Creek	970102	1997	AUG	24
	10	0.4	Canal Creek	970090	1997	AUG	13
Cobalt	1	2.9	O-Field	970092	1997	JUL	21
	2	2.8	O-Field	970104	1997	JUL	29
	3	2.5	Cluster 13	9972901	1999	SEP	20
	4	2.332	Cluster 3	31	2000	AUG	22
	5	2	Tower Hill	9977101	1999	OCT	8
	6	1.9	Cluster 13	9972901	1999	SEP	20
	7	1.9	J-Field	JFA1	1999	JUN	5
	8	1.5	O-Field	96-1094	1996	SEP	29
	9	1	O-Field	970058	1997	JUL	21
	10	1	O-Field	970114	1997	JUL	29
Chromium	1	1.6	O-Field	970092	1997	JUL	21
	2	1.6	Bush River	970073	1997	AUG	11
	3	1.122	Eastern Shore	36	2000	SEP	23
	4	1.1	Canal Creek	970113	1997	AUG	24
	5	1	O-Field	970093	1997	AUG	22
	6	0.907	Eastern Shore	44	2000	OCT	16
	7	0.9	O-Field	970114	1997	JUL	29
	8	0.9	O-Field	970112	1997	AUG	15
	9	0.853	Eastern Shore	29	2000	AUG	23
	10	0.8	O-Field	970058	1997	JUL	21
Cesium	1	0.3	Canal Creek	970113	1997	AUG	24
	2	0.2	Canal Creek	970056	1997	JUL	21
	3	0.1	Bush River	970085	1997	AUG	11
	4	0.057	J-Field	30	2000	AUG	28
	5	0.027	Cluster 3	27	2000	AUG	22
	6	0.025	J-Field	41	2000	AUG	28
	7	0.024	J-Field	50	2000	AUG	28
	8	0.008	Cluster 3	31	2000	AUG	22
	9	0.008	Cluster 3	37	2000	AUG	22
	10	0.008	J-Field	34	2000	AUG	28
Copper	1	68.6	Canal Creek	970090	1997	AUG	13
	2	39.4	O-Field	970058	1997	JUL	21
	3	39	O-Field	970104	1997	JUL	29
	4	38.7	O-Field	970110	1997	JUL	29
	5	38.5	O-Field	970062	1997	AUG	12
	6	38.3	O-Field	970111	1997	JUL	29
	7	37.9	O-Field	970051	1997	AUG	12
	8	35.8	O-Field	970092	1997	JUL	21
	9	35.4	O-Field	970061	1997	AUG	12
	10	34.8	O-Field	970057	1997	JUL	21
Gallium	1	3.1	O-Field	970117	1997	AUG	19
	2	2.3	O-Field	970068	1997	JUL	29
	3	2	Canal Creek	970056	1997	JUL	21
	4	1.9	O-Field	970051	1997	AUG	12
	5	1.9	O-Field	970094	1997	AUG	12
	6	1.8	O-Field	970110	1997	JUL	29
	7	1.8	O-Field	970057	1997	JUL	21
	8	1.7	O-Field	970076	1997	AUG	15
	9	1.6	O-Field	970111	1997	JUL	29

	10	1.5	O-Field	970097	1997	AUG	12
Manganese	1	763	Canal Creek	970056	1997	JUL	21
	2	655	O-Field	970068	1997	JUL	29
	3	468	O-Field	970114	1997	JUL	29
	4	441	O-Field	970094	1997	AUG	12
	5	440	O-Field	970110	1997	JUL	29
	6	432	O-Field	970051	1997	AUG	12
	7	427	Canal Creek	970053	1997	JUL	21
	8	418	Canal Creek	970052	1997	JUL	21
	9	407	O-Field	970076	1997	AUG	15
	10	403	O-Field	970111	1997	JUL	29
Nickel	1	84.7	Bush River	970082	1997	AUG	11
	2	20.9	O-Field	970093	1997	AUG	22
	3	20.1	Bush River	970074	1997	AUG	11
	4	13.8	Bush River	970084	1997	AUG	11
	5	12.6	O-Field	970100	1997	AUG	15
	6	12	O-Field	970129	1997	AUG	4
	7	10.7	Bush River	970137	1997	AUG	11
	8	10.4	Bush River	970072	1997	AUG	11
	9	9.5	Bush River	970125	1997	AUG	11
	10	9.1	Bush River	970083	1997	AUG	11
Lead	1	85	J-Field	JFE1	1999	JUN	5
	2	67.6	Bush River	970137	1997	AUG	11
	3	45.8	Bush River	970126	1997	AUG	11
	4	45.427	Eastern Shore	36	2000	SEP	23
	5	28	Bush River	970125	1997	AUG	11
	6	27.6	Bush River	970084	1997	AUG	11
	7	27.2	O-Field	970132	1997	AUG	15
	8	26.6	Bush River	970140	1997	AUG	11
	9	25.9	Bush River	970074	1997	AUG	11
	10	24.8	Bush River	970083	1997	AUG	11
Rubidium	1	77.5	O-Field	970058	1997	JUL	21
	2	40.9	O-Field	970108	1997	JUL	29
	3	38.7	O-Field	970062	1997	AUG	12
	4	37.3	O-Field	970057	1997	JUL	21
	5	36.3	O-Field	970055	1997	JUL	21
	6	30.6	Bush River	970127	1997	AUG	11
	7	30.3	O-Field	970123	1997	AUG	4
	8	27.5	O-Field	970124	1997	AUG	4
	9	27.2	Bush River	970078	1997	AUG	11
	10	26.7	O-Field	970105	1997	JUL	29
Selenium	1	1.067	Eastern Shore	36	2000	SEP	23
	2	1	O-Field	970058	1997	JUL	21
	3	1	O-Field	970097	1997	AUG	12
	4	1	O-Field	970095	1997	AUG	12
	5	0.9	O-Field	970104	1997	JUL	29
	6	0.9	O-Field	970092	1997	JUL	21
	7	0.9	O-Field	970111	1997	JUL	29
	8	0.9	O-Field	970114	1997	JUL	29
	9	0.9	O-Field	970093	1997	AUG	22
	10	0.8	O-Field	970057	1997	JUL	21
Strontium	1	25.6	O-Field	970110	1997	JUL	29

	2	25.5	O-Field	970068	1997	JUL	29
	3	24.5	O-Field	970111	1997	JUL	29
	4	23	O-Field	970062	1997	AUG	12
	5	22.4	O-Field	970108	1997	JUL	29
	6	21	O-Field	970104	1997	JUL	29
	7	20.6	O-Field	970094	1997	AUG	12
	8	20.3	O-Field	970051	1997	AUG	12
	9	18	O-Field	970061	1997	AUG	12
	10	17.9	O-Field	970114	1997	JUL	29
Titanium	1	0.5	J-Field	9973403	1999	SEP	13
	2	0.4	Bush River	970085	1997	AUG	11
	3	0.2	Canal Creek	970113	1997	AUG	24
	4	0.109	Eastern Shore	36	2000	SEP	23
	5	0.103	Cluster 3	48	2000	AUG	22
	6	0.1	O-Field	970097	1997	AUG	12
	7	0.1	Canal Creek	970103	1997	AUG	4
	8	0.1	Canal Creek	970056	1997	JUL	21
	9	0.1	Otter Creek	9977901	1999	SEP	27
	10	0.1	Lorh's Orchard	9977401	1999	SEP	20
Uranium	1	0.2	Canal Creek	970113	1997	AUG	24
	2	0.1	Bush River	970085	1997	AUG	11
	3	0.1	O-Field	970097	1997	AUG	12
	4	0.1	Canal Creek	970103	1997	AUG	4
	5	0.1	Canal Creek	970056	1997	JUL	21
	6	0.023	Eastern Shore	36	2000	SEP	23
	7	0.014	Cluster 3	48	2000	AUG	22
	8	0.011	Eastern Shore	43	2000	SEP	18
	9	0.004	J-Field	49	2000	AUG	28
	10	0.003	J-Field	41	2000	AUG	28
Vanadium	1	1.8	O-Field	970092	1997	JUL	21
	2	1.7	Bush River	970073	1997	AUG	11
	3	1.6	Canal Creek	970113	1997	AUG	24
	4	1.5	O-Field	970095	1997	AUG	12
	5	1.4	O-Field	970094	1997	AUG	12
	6	1.4	O-Field	970091	1997	JUL	21
	7	1.3	Bush River	970119	1997	AUG	11
	8	1.3	O-Field	970114	1997	JUL	29
	9	1.3	O-Field	970112	1997	AUG	15
	10	1.3	O-Field	970093	1997	AUG	22
Zinc	1	8060.68	Eastern Shore	36	2000	SEP	23
	2	804	Youth Center	9977601	1999	SEP	20
	3	257	Otter Creek	9973901	1999	SEP	27
	4	229	J-Field	JFC3	1999	JUN	5
	5	229	Jones Farm	9973201	1999	SEP	20
	6	205	Canal Creek	970138	1997	AUG	24
	7	195	Canal Creek	970090	1997	AUG	13
	8	172.696	Cluster 3	46	2000	AUG	22
	9	170	Silver Lake	9974601	1999	SEP	28
	10	169	O-Field	970092	1997	JUL	21

TABLE 8.9.6 Three Highest Sample Concentrations For Pesticides in Bees
(Ranked From Highest to Lowest; 1-3 Respectively) (microgram/kilogram)
Samples Collected in 1998 and 1999.

Compound	Rank	Conc	Location	Sample ID	Year	Month	Day
4,4-DDD	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
4,4-DDE	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
4,4-DDT	1	83.8	J-Field	JFLDLB9903	1999	JAN	5
	2	37.1	Lohr's Orchard	LOLB9903	1999	JAN	5
	3	36.1	J-Field	JFLDLB9902	1999	JAN	5
Aldrin	1	10	Shawsville	SVLB9903	1999	JAN	5
	2	3.04	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
Alpha-BHC	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Alpha-Chlorodane	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Beta-BHC	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Chlorodane	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Delta-BHC	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Dieldrin	1	17.4	J-Field	JFLDLB9902	1999	JAN	5
	2	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9903	1999	JAN	5
Endosulfan I	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Endosulfan II	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Endosulfan Sulfate	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Eldrin	1	34.9	Silver Lake Drive	SLLB9903	1999	JAN	5
	2	26.9	Canal Creek	CCLB9903	1999	JAN	5
	3	26.6	Lohr's Orchard	LOLB9903	1999	JAN	5
Eldrin Aldehyde	1	259	J-Field	JFLDLB9903	1999	JAN	5
	2	190	Cylburn Arboretum	ABLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5

Eldrin Keytone	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Gamma-BHC	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Gamma-Chlorodane	1	98.8	Churchville	CVDB9801	1999	JAN	5
	2	86.1	Tower Hill Farm	THLB9903	1999	JAN	5
	3	80.8	J-Field	JFLDDB9903	1999	JAN	5
Heptachlor	1	1260	Lohr's Orchard	LOLB9903	1999	JAN	5
	2	737	Tower Hill Farm	THLB9903	1999	JAN	5
	3	712	J-Field	JFLDDB9903	1999	JAN	5
Heptachlor Epoxide	1	53.7	J-Field	JFLDLB9903	1999	JAN	5
	2	28	Canal Creek	CCLB9903	1999	JAN	5
	3	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
Methoxychlor	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
Toxphene	1	-99	Cylburn Arboretum	ABLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDLB9902	1999	JAN	5
PCB-1016	1	-99	J-Field	JFLDLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9902	1999	JAN	5
	3	-99	J-Field	JFLDDB9903	1999	JAN	5
PCB-1221	1	-99	J-Field	JFLDLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9902	1999	JAN	5
	3	-99	J-Field	JFLDDB9903	1999	JAN	5
PCB-1232	1	-99	J-Field	JFLDLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9902	1999	JAN	5
	3	-99	J-Field	JFLDDB9903	1999	JAN	5
PCB-1242	1	-99	J-Field	JFLDLB9903	1999	JAN	5
	2	-99	J-Field	JFLDLB9902	1999	JAN	5
	3	-99	J-Field	JFLDDB9903	1999	JAN	5
PCB-1248	1	235	J-Field	JFLDLB9902	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDDB9903	1999	JAN	5
PCB-1254	1	472	J-Field	JFLDLB9902	1999	JAN	5
	2	-99	J-Field	JFLDLB9903	1999	JAN	5
	3	-99	J-Field	JFLDDB9903	1999	JAN	5
PCB-1260	1	588	J-Field	JFLDLB9903	1999	JAN	5
	2	433	Shawsville	SVLB9903	1999	JAN	5
	3	396	Cluster 3	CL3LB9902	1999	JAN	5

-99 Represents Below Detectable Limits. All columns with only -99 are arbitrarily sorted by concentration.

TABLE 8.9.7 Three Highest Sample Concentrations For Pesticides in Pollen
(Ranked From Highest to Lowest; 1-3 Respectively) (microgram/kilogram)
Samples Collected in 1998 and 1999.

Compound	Rank	Conc	Location	Sample ID	Year	Month	Day
4,4-DDD	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
4,4-DDE	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
4,4-DDT	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Aldrin	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Alpha-BHC	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Alpha-Chlorodane	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Beta-BHC	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Chlorodane	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Delta-BHC	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Dieldrin	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Endosulfan I	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Endosulfan II	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Endosulfan Sulfate	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Eldrin	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Eldrin Aldehyde	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5

Eldrin Keytone	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Gamma-BHC	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Gamma-Chlorodane	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Heptachlor	1	130	J-Field	JFLDPL9903	1999	JAN	5
	2	68	Cluster 3	CL3PL9902	1999	JAN	5
	3	45.8	Churchville	CVPL9801	1999	JAN	5
Heptachlor Epoxide	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Methoxychlor	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
Toxphene	1	-99	J-Field	JFLDPL9903	1999	JAN	5
	2	-99	Cluster 3	CL3PL9902	1999	JAN	5
	3	-99	Churchville	CVPL9801	1999	JAN	5
PCB-1016	1	-99	Churchville	CVPL9801	1999	JAN	5
	2		J-Field	JFLDPL9903	1999	JAN	5
	3		Cluster 3	CL3PL9902	1999	JAN	5
PCB-1221	1	-99	Churchville	CVPL9801	1999	JAN	5
	2		J-Field	JFLDPL9903	1999	JAN	5
	3		Cluster 3	CL3PL9902	1999	JAN	5
PCB-1232	1	-99	Churchville	CVPL9801	1999	JAN	5
	2		J-Field	JFLDPL9903	1999	JAN	5
	3		Cluster 3	CL3PL9902	1999	JAN	5
PCB-1242	1	-99	Churchville	CVPL9801	1999	JAN	5
	2		J-Field	JFLDPL9903	1999	JAN	5
	3		Cluster 3	CL3PL9902	1999	JAN	5
PCB-1248	1	-99	Churchville	CVPL9801	1999	JAN	5
	2		J-Field	JFLDPL9903	1999	JAN	5
	3		Cluster 3	CL3PL9902	1999	JAN	5
PCB-1254	1	-99	Churchville	CVPL9801	1999	JAN	5
	2		J-Field	JFLDPL9903	1999	JAN	5
	3		Cluster 3	CL3PL9902	1999	JAN	5
PCB-1260	1	-99	Churchville	CVPL9801	1999	JAN	5
	2		J-Field	JFLDPL9903	1999	JAN	5
	3		Cluster 3	CL3PL9902	1999	JAN	5

-99 Represents Below Detectable Limits. All columns with only -99 are arbitrarily sorted by concentration.

TABLE 8.9.8 Ten Highest Sample Concentrations For Radionuclides in Bees
(Ranked From Highest to Lowest; 1-3 Respectively) (pCI/g)
Samples Collected in 1998 and 1999, Analysis Report Verified January 99.

Compound	Rank	Conc	Location	Sample ID	Year	Month	Day
Cs-137	1	0.561	Rumsey Mansion	RMLB9901	1999	JAN	2
	2	0.499	Lohr's Orchard	LOLB9901	1999	JAN	2
	3	0.331	J-Field	JFLB9901	1999	JAN	2
	4	0.33	Cluster 13	CL3DB9901	1999	JAN	2
	5	0.315	Cylburn Arboretum	ABLB9902	1999	JAN	2
	6	0.264	Tower Hill Farm	THLB9902	1999	JAN	2
	7	0.246	Canal Creek	CCLB9902	1999	JAN	2
	8	0.235	Carroll Island	CILB9801	1998	JAN	2
	9	0.214	Cluster 13	CL3LB9901	1999	JAN	2
	10	0.201	J-Field	JFLDLB9901	1999	JAN	2
Co-60	1	13	Silver Lake Drive	SLLB9902	1999	JAN	2
	2	12.9	Lohr's Orchard	LOLB9901	1999	JAN	2
	3	11.8	Tower Hill Farm	THLB9902	1999	JAN	2
	4	10.1	J-Field	JFLDLB9901	1999	JAN	2
	5	0.635	Rumsey Mansion	RMLB9901	1999	JAN	2
	6	0.452	Cluster 13	CL3DB9901	1999	JAN	2
	7	0.206	Churchville	CVLB9901	1999	JAN	2
	8	0.17	Cylburn Arboretum	ABLB9901	1999	JAN	2
	9	0.17	J-Field	JFLDDB9901	1999	JAN	2
	10	0.158	Westwood Road	WWLB9802	1998	JAN	2
K-40	1	17.5	Silver Lake Drive	SLLB9901	1999	JAN	2
	2	15.3	Rumsey Mansion	RMLB9901	1999	JAN	2
	3	15	Cluster 13	CL13LB9901	1999	JAN	2
	4	14.3	J-Field	JFLDDB9901	1999	JAN	2
	5	13.6	Cylburn Arboretum	ABLB9901	1999	JAN	2
	6	13.3	Lohr's Orchard	LOLB9902	1999	JAN	2
	7	13.2	J-Field	JFLB9902	1999	JAN	2
	8	13.1	Youth Center	YCLB9901	1999	JAN	2
	9	12.1	Canal Creek	CCLB9901	1999	JAN	2
	10	12	Cluster 13	CL3DB9901	1999	JAN	2
Th-228	1	1.2	Rumsey Mansion	RMLB9902	1999	JAN	2
	2	0.949	J-Field	JFDDB9902	1999	JAN	2
	3	0.639	Silver Lake Drive	SLLB9901	1999	JAN	2
	4	0.421	Shawsville	SVLB9902	1999	JAN	2
	5	0.353	Youth Center	YCLB9901	1999	JAN	2
	6	0.331	Canal Creek	CCLB9902	1999	JAN	2
	7	0.327	Lohr's Orchard	LOLB9902	1999	JAN	2
	8	0.254	Otter Creek Drive	OPLB9901	1999	JAN	2
	9	0.248	Rumsey Mansion	RMLB9901	1999	JAN	2
	10	0.246	Cylburn Arboretum	ABLB9902	1999	JAN	2

-99 Represents Below Detectable Limits. All columns with only -99 are arbitrarily sorted by concentration.

TABLE 8.9.9 Ten Highest Sample Concentrations For Radionuclides in Pollen
(Ranked From Highest to Lowest; 1-3 Respectively) (pCi/g)
Samples Collected in 1998 and 1999, Analysis Report Verified January 99.

Compound	Rank	Conc	Location	Sample ID	Year	Month	Day
Cs-137	1	0.311	J-Field	JFDPL9901	1999	JAN	2
	2	0.305	J-Field	JFPL9901	1999	JAN	2
	3	0.22	Rumsey Mansion	RMPL9901	1999	JAN	2
	4	0.134	Youth Center	YCPL9901	1999	JAN	2
	5	0.127	Tower Hill Farm	THPL9901	1999	JAN	2
	6	0.112	Cylburn Arb	ABPL9901	1999	JAN	2
	7	0.063	Lohr's Orchard	LOPL9901	1999	JAN	2
	8	0.0461	Churchville	CVPL9901	1999	JAN	2
	9	0.0448	Shawsville	SVPL9901	1999	JAN	2
	10	0.00245	Cluster 13	CL3PL9901	1999	JAN	2
Co-60	1	7.83	J-Field	JFDPL9902	1999	JAN	2
	2	1.94	Cluster 13	CL3PL9901	1999	JAN	2
	3	0.127	Tower Hill Farm	THPL9901	1999	JAN	2
	4	0.0888	Churchville	CVPL9901	1999	JAN	2
	5	0.0797	Shawsville	SVPL9901	1999	JAN	2
	6	0.0792	J-Field	JFPL9901	1999	JAN	2
	7	0.0788	Youth Center	YCPL9901	1999	JAN	2
	8	0.0581	Lohr's Orchard	LOPL9901	1999	JAN	2
	9	0.0478	Shawsville	SVLB9901	1999	JAN	2
	10	0.0297	Cylburn Arb	ABPL9901	1999	JAN	2
K-40	1	10.2	Shawsville	SVLB9901	1999	JAN	2
	2	9.23	J-Field	JFDPL9901	1999	JAN	2
	3	8.84	Rumsey Mansion	RMPL9901	1999	JAN	2
	4	7.18	Cylburn Arb	ABPL9901	1999	JAN	2
	5	6.49	Shawsville	SVPL9901	1999	JAN	2
	6	5.54	J-Field	JFPL9901	1999	JAN	2
	7	5.09	Otter Creek Dr	OPPL9901	1999	JAN	2
	8	4.97	Canal Creek	CCPL9901	1999	JAN	2
	9	4.78	Silver Lake Dr	SLPL9901	1999	JAN	2
	10	1.7	Lohr's Orchard	LOPL9901	1999	JAN	2
Th-228	1	8.38	Tower Hill Farm	THPL9901	1999	JAN	2
	2	0.426	Shawsville	SVLB9901	1999	JAN	2
	3	0.294	Lohr's Orchard	LOPL9901	1999	JAN	2
	4	0.241	Churchville	CVPL9901	1999	JAN	2
	5	0.173	Rumsey Mansion	RMPL9901	1999	JAN	2
	6	0.168	J-Field	JFDPL9902	1999	JAN	2
	7	0.161	Otter Creek Dr	OPPL9901	1999	JAN	2
	8	0.161	Canal Creek	CCPL9901	1999	JAN	2
	9	0.156	Silver Lake Dr	SLPL9901	1999	JAN	2
	10	0.0669	Youth Center	YCPL9901	1999	JAN	2

-99 Represents Below Detectable Limits. All columns with only -99 are arbitrarily sorted by concentration.

Relevant References

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Appendix A:

Data Base Inventory

TABLE A.1
Sites sorted by the year sampled.

YEAR	2000
SITE	ABRV.
J - Field	JF
Cluster 3	CL3
East Shore	ES

YEAR	1999
SITE	ABRV.
Churchville	CV
Cluster 13	CL13
Cluster 3	CL3
Conowingo Orchard	CO
Cylburn Arboretum	CA
J - Field	JF
Jones Farm	JO
Lohr's Orchard	LO
Otter Creek Drive	OP
Rumsey Island	RI
Shawsville	SV
Silver Lake Drive	SL
Tower Hill Farm	TH
Youth Center	YC

YEAR	1996
SITE	ABRV.
Beach Point	BP
Canal Creek	CC
Churchville	CV
David Simmon's	DS
East Branch Canal Creek	EB
G - Street	GS
Jim Zinc's	JZ
Lauderick Creek	LC
National Guard Armory	NG
O - Field	OF
Youth Center	YC

YEAR	1998
SITE	ABRV.
Aberdeen Post	AP
Carroll Island	CI
Churchville	CV
Cluster 13	CL13
Conowingo Orchard	CO
Cylburn Arboretum	CA
D - Field	DF
Grace's Quarters	GQ
J - Field	JF
Jones Farm	JO
Lohr's Orchard	LO
O - Field	OF
Otter Creek Drive	OP
Rumsey Mansion	RM
Shawsville	SV
Silver Lake Drive	SL
Tower Hill Farm	TH
Westwood Road	WW
Youth Center	YC

YEAR	1997
SITE	ABRV.
Beach Point	BP
Bush River	BR
Canal Creek	CC
Churchville	CV
East Branch Canal Creek	EB
G - Street	GS
J - Field	JF
Lauderick Creek	LC
National Guard Armory	NG
O - Field	OF
West Branch Canal Creek	WB
Youth Center	YC

Table A.2

Volatile Organic Compounds and their properties sorted by the year sampled.

YEAR 2000

Name of organic compound used in 2000	Formula	Molecular Weight		Name of organic compound used in 2000	Formula	Molecular Weight
1,1-Dichloroethane	C2H2Cl2	96.95		m,p-Xylenes	C8H10	106.16
Dichloromethane	CH2Cl2	84.94		o-Xylene	C8H10	106.16
trans-1,2-Dichloroethene	C2H2Cl2	96.95		Styrene (Ethenylbenzene)	C8H8	104.14
1,1-Dichloroethene	C2H4Cl2	98.97		Isopropylbenzene	C9H12	120.19
2,2-Dichloropropane	C3H6Cl2	112.99		Tribromomethane	CHBr3	252.77
cis-1,2-Dichloroethene	C2H2Cl2	96.95		1,1,2,2-Tetrachloroethane	C2H2Cl4	167.86
Trichloromethane	CHCl3	119.39		1-Bromo-4-fluorobenzene	C6H4BrF	175
Bromochloromethane	CH2BrCl	129.38		n-Propylbenzene	C9H12	120.19
1,1,1-Trichloroethane	C2H3Cl3	133.42		Bromobenzene	C6H5Br	157.02
1,1-Dichloropropane	C3H4Cl2	110.98		1,3,5-Trimethylbenzene	C9H12	120.19
Tetrachloromethane	CCl4	153.84		2-Chlorotoluene	C7H7Cl	126.58
1,2-Dichloroethane	C2H4Cl2	98.97		4-Chlorotoluene	C7H7Cl	126.58
Benzene	C6H6	78.11		*tert*-Butylbenzene	C10H14	134.21
Trichloroethene	C2HCl3	131.38		1,2,4-Trimethylbenzene	C9H12	120.19
1,2-Dichloropropane	C3H6C2	100.98		Benzaldehyde	C7H6O	106.12
Bromodichloromethane	CHBrCl2	163.83		*sec*-Butylbenzene	C10H14	134.21
Dibromomethane	CH2Br2	173.86		Isopropyltoluene	C10H14	134.21
cis-1,3-Dichloro-1-propene	C3H4Cl2	110.98		1,3-Dichlorobenzene	C6H4Cl2	147.01
Toluene	C7H8	92.13		1,4-Dichlorobenzene	C6H4Cl2	147.01
trans-1,3-Dichloropropene	C3H4Cl2	110.98		n-Butylbenzene	C10H14	134.21
1,1,2-Trichloroethane	C2H3Cl3	133.42		1,2-d4-Dichlorobenzene	C6H4Cl2	147.01
1,3-Dichloropropane	C3H6Cl2	112.99		1,2-Dichlorobenzene	C6H4Cl2	147.01
Tetrachloroethene	C2Cl4	165.85		Hexachloroethane	C2Cl6	238.52
Dibromochloromethane	CHBr2Cl	208.28		Acetophenone	C8H8O	120.15
1,2-Dibromoethane	C2H4Br2	187.88		1,2-Dibromo-3d-chloropropane	C3H5Br2Cl	236.36
Chlorobenzene	C6H5Cl	112.56		1,2,4-Trichlorobenzene	C6H3Cl3	181.46
1,1,1,2-tetrachloroethane	C2H2Cl4	167.86		Naphthalene	C10H8	128.16
Ethylbenzene	C8H10	106.16		1,2,3-trichlorobenzene	C6H3Cl3	181.46

TABLE A.2 continued YEAR 1999

Name of organic compound used in 1999	Formula	Molecular Weight		Name of organic compound used in 1999	Formula	Molecular. Weight
1,1-Dichloroethane	C2H2Cl2	96.95		m,p-Xylenes	C8H10	106.16
Dichloromethane	CH2Cl2	84.94		o-Xylene	C8H10	106.16
trans-1,2-Dichloroethene	C2H2Cl2	96.95		Styrene (Ethenylbenzene)	C8H8	104.14
1,1-Dichloroethene	C2H4Cl2	98.97		Isopropylbenzene	C9H12	120.19
2,2-Dichloropropane	C3H6Cl2	112.99		Tribromomethane	CHBr3	252.77
cis-1,2-Dichloroethene	C2H2Cl2	96.95		1,1,2,2-Tetrachloroethane	C2H2Cl4	167.86
Trichloromethane	CHCl3	119.39		1-Bromo-4-fluorobenzene	C6H4BrF	175
Bromochloromethane	CH2BrCl	129.38		n-Propylbenzene	C9H12	120.19
1,1,1-Trichloroethane	C2H3Cl3	133.42		Bromobenzene	C6H5Br	157.02
1,1-Dichloropropene	C3H4Cl2	110.98		1,3,5-Trimethylbenzene	C9H12	120.19
Tetrachloromethane	CCl4	153.84		2-Chlorotoluene	C7H7Cl	126.58
1,2-Dichloroethane	C2H4Cl2	98.97		4-Chlorotoluene	C7H7Cl	126.58
Benzene	C6H6	78.11		*tert*-Butylbenzene	C10H14	134.21
Trichloroethene	C2HCl3	131.38		1,2,4-Trimethylbenzene	C9H12	120.19
1,2-Dichloropropane	C3H6C2	100.98		Benzaldehyde	C7H6O	106.12
Bromodichloromethane	CHBrCl2	163.83		*sec*-Butylbenzene	C10H14	134.21
Dibromomethane	CH2Br2	173.86		Isopropyltoluene	C10H14	134.21
cis-1,3-Dichloro-1-propene	C3H4Cl2	110.98		1,3-Dichlorobenzene	C6H4Cl2	147.01
Toluene	C7H8	92.13		1,4-Dichlorobenzene	C6H4Cl2	147.01
trans-1,3-Dichloropropene	C3H4Cl2	110.98		n-Butylbenzene	C10H14	134.21
1,1,2-Trichloroethane	C2H3Cl3	133.42		1,2-d4-Dichlorobenzene	C6H4Cl2	147.01
1,3-Dichloropropane	C3H6Cl2	112.99		1,2-Dichlorobenzene	C6H4Cl2	147.01
Tetrachloroethene	C2Cl4	165.85		Hexachloroethane	C2Cl6	238.52
Dibromochloromethane	CHBr2Cl	208.28		Acetophenone	C8H8O	120.15
1,2-Dibromoethane	C2H4Br2	187.88		1,2-Dibromo-3d-chloropropane	C3H5Br2Cl	236.36
Chlorobenzene	C6H5Cl	112.56		1,2,4-Trichlorobenzene	C6H3Cl3	181.46
1,1,1,2-tetrachloroethane	C2H2Cl4	167.86		Naphthalene	C10H8	128.16
Ethylbenzene	C8H10	106.16		1,2,3-trichlorobenzene	C6H3Cl3	181.46

Table A:2 continued

YEAR 1998

Name of organic compound used in 1998	Formula	Molecular Weight
Tetrachloromethane	CCl4	153.84
Benzene	C6H6	78.11
Toluene	C7H8	92.13
Ethylbenzene	C8H10	106.16
Trichloroethene	C2HCl3	131.4
1,4-Dichlorobenzene	C6H4Cl2	147.01
Naphthalene	C10H8	128.16
Tetetrachloroethene	C2Cl4	165.85
Benzaldehyde	C7H6O	106.12
Acetophenone	C8H8O	120.15

YEAR 1997

Name of organic compound used in 1997	Formula	Molecular Weight
Tetrachloromethane	CCl4	153.84
Benzene	C6H6	78.11
Toluene	C7H8	92.13
Ethylbenzene	C8H10	106.16
Trichloroethene	C2HCl3	131.4
1,4-Dichlorobenzene	C6H4Cl2	147.01
Naphthalene	C10H8	128.16
Tetetrachloroethene	C2Cl4	165.85
Benzaldehyde	C7H6O	106.12
Acetophenone	C8H8O	120.15

YEAR 1996

Name of organic compound used in 1996	Formula	Molecular Weight
Tetrachloromethane	CCl4	153.84
Toluene	C7H8	92.13
Ethylbenzene	C8H10	106.16
Trichloroethene	C2HCl3	131.4
1,4-Dichlorobenzene	C6H4Cl2	147.01
Naphthalene	C10H8	128.16
Tetetrachloroethene	C2Cl4	165.85
Benzaldehyde	C7H6O	106.12
Acetophenone	C8H8O	120.15

Table A.3

Trace elements and heavy metals measured over all years.

YEAR **1996 - 2000**

Symbol	Element
As	Arsenic
Ba	Barium
Be	Beryllium
Bi	Bismuth
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cs	Cesium
Cu	Copper
Ga	Gallium
Mn	Manganese
Pb	Lead
Rb	Rubidium
Se	Selenium
Sr	Strontium
Ti	Titanium
U	Uranium
V	Vanadium
Zn	Zinc

Table A.4

Radionuclides, Pesticides, and PCBs quantified in 1998 and 1999

Radionuclides
Cesium - 137
Cobalt - 60
Potassium - 40
Thorium - 228

Pesticides
4,4-DDD
4,4-DDE
4,4-DDT
Aldrin
Alpha-BHC
Alpha-Chlordane
Beta-BHC
Chlordane
Delta-BHC
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Eldrin Ketone
Gamma-BHC
Gamma-Chlordane
Heptachlor
Heptachlor Epoxide
Methoxychlor
Toxaphene
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260

TABLE A.5

Dates and file numbers of volatile organic compound data sorted by given year and location.

YEAR: **2000**
LOCATION: **J - FIELD**

DAY	MONTH	YEAR	FILE	LOCATION
3	JAN	2000	663.2	J-Field
3	JAN	2000	663.3	J-Field
6	JAN	2000	513.2	J-Field
17	FEB	2000	529.2	J-Field
6	APR	2000	513.1	J-Field
6	APR	2000	513.4	J-Field
6	APR	2000	513.5	J-Field
6	APR	2000	513.6	J-Field
6	APR	2000	516.1	J-Field
6	APR	2000	516.1	J-Field
6	APR	2000	516.2	J-Field
6	APR	2000	516.3	J-Field
6	APR	2000	516.6	J-Field
6	APR	2000	516.7	J-Field
6	APR	2000	516.9	J-Field
19	APR	2000	516.1	J-Field
19	APR	2000	516.1	J-Field
19	APR	2000	516.1	J-Field
19	APR	2000	516.1	J-Field
19	APR	2000	520.1	J-Field
19	APR	2000	520.2	J-Field
19	APR	2000	520.3	J-Field
19	APR	2000	520.4	J-Field
19	APR	2000	520.5	J-Field
19	APR	2000	520.7	J-Field
19	APR	2000	520.8	J-Field
19	APR	2000	521.2	J-Field
19	APR	2000	521.3	J-Field
19	APR	2000	521.4	J-Field
19	APR	2000	521.5	J-Field
19	APR	2000	521.6	J-Field
19	APR	2000	521.7	J-Field
19	APR	2000	521.8	J-Field
19	APR	2000	523.1	J-Field
19	APR	2000	523.5	J-Field
19	APR	2000	523.6	J-Field
19	APR	2000	520.6	J-Field
3	MAY	2000	523.1	J-Field
3	MAY	2000	523.7	J-Field
3	MAY	2000	523.8	J-Field
3	MAY	2000	523.9	J-Field

DAY	MONTH	YEAR	FILE	LOCATION
3	MAY	2000	524.1	J-Field
3	MAY	2000	524.2	J-Field
3	MAY	2000	524.3	J-Field
3	MAY	2000	524.4	J-Field
3	MAY	2000	524.5	J-Field
3	MAY	2000	524.6	J-Field
3	MAY	2000	524.7	J-Field
3	MAY	2000	524.8	J-Field
3	MAY	2000	526.1	J-Field
3	MAY	2000	526.1	J-Field
3	MAY	2000	526.1	J-Field
3	MAY	2000	526.2	J-Field
3	MAY	2000	526.3	J-Field
3	MAY	2000	526.4	J-Field
3	MAY	2000	526.5	J-Field
3	MAY	2000	526.6	J-Field
3	MAY	2000	526.7	J-Field
3	MAY	2000	526.8	J-Field
3	MAY	2000	526.9	J-Field
14	MAY	2000	529.4	J-Field
17	MAY	2000	529.1	J-Field
17	MAY	2000	529.3	J-Field
17	MAY	2000	529.5	J-Field
17	MAY	2000	529.6	J-Field
17	MAY	2000	529.7	J-Field
17	MAY	2000	529.8	J-Field
17	MAY	2000	532.8	J-Field
17	MAY	2000	541.1	J-Field
17	MAY	2000	541.2	J-Field
17	MAY	2000	541.3	J-Field
17	MAY	2000	541.4	J-Field
17	MAY	2000	541.5	J-Field
17	MAY	2000	541.6	J-Field
17	MAY	2000	541.7	J-Field
17	MAY	2000	541.8	J-Field
17	MAY	2000	544.1	J-Field
17	MAY	2000	544.2	J-Field
17	MAY	2000	544.3	J-Field
17	MAY	2000	544.4	J-Field
17	MAY	2000	544.6	J-Field
17	MAY	2000	544.7	J-Field

TABLE A.5 continued

YEAR: **2000**

LOCATION: **J - FIELD continued**

DAY	MONTH	YEAR	FILE	LOCATION
1	JUN	2000	547.1	J-Field
1	JUN	2000	547.1	J-Field
1	JUN	2000	547.1	J-Field
1	JUN	2000	547.1	J-Field
1	JUN	2000	547.1	J-Field
1	JUN	2000	547.1	J-Field
1	JUN	2000	547.2	J-Field
1	JUN	2000	547.2	J-Field
1	JUN	2000	547.4	J-Field
1	JUN	2000	547.9	J-Field
1	JUN	2000	550.1	J-Field
1	JUN	2000	550.1	J-Field
1	JUN	2000	550.1	J-Field
1	JUN	2000	550.1	J-Field
1	JUN	2000	550.2	J-Field
1	JUN	2000	550.3	J-Field
1	JUN	2000	550.4	J-Field
1	JUN	2000	550.5	J-Field
1	JUN	2000	550.6	J-Field
1	JUN	2000	550.7	J-Field
1	JUN	2000	550.8	J-Field
10	JUN	2000	550.1	J-Field
13	JUN	2000	626.5	J-Field
1	AUG	2000	602.1	J-Field
1	AUG	2000	602.2	J-Field
1	AUG	2000	602.6	J-Field
1	AUG	2000	602.8	J-Field
1	AUG	2000	604.2	J-Field
1	AUG	2000	604.7	J-Field
1	AUG	2000	610.3	J-Field
1	AUG	2000	610.4	J-Field
13	SEP	2000	623.1	J-Field
13	SEP	2000	623.2	J-Field
13	SEP	2000	623.3	J-Field
13	SEP	2000	623.4	J-Field
13	SEP	2000	623.5	J-Field
13	SEP	2000	623.6	J-Field
13	SEP	2000	623.7	J-Field

DAY	MONTH	YEAR	FILE	LOCATION
13	SEP	2000	623.8	J-Field
13	SEP	2000	625.2	J-Field
13	SEP	2000	625.3	J-Field
13	SEP	2000	625.4	J-Field
13	SEP	2000	625.5	J-Field
13	SEP	2000	625.6	J-Field
13	SEP	2000	625.7	J-Field
13	SEP	2000	626.1	J-Field
13	SEP	2000	626.2	J-Field
13	SEP	2000	626.3	J-Field
13	SEP	2000	626.4	J-Field
13	SEP	2000	626.6	J-Field
13	SEP	2000	626.7	J-Field
28	SEP	2000	660.1	J-Field
28	SEP	2000	660.2	J-Field
28	SEP	2000	660.6	J-Field
28	SEP	2000	660.8	J-Field
28	SEP	2000	661.1	J-Field
28	SEP	2000	661.2	J-Field
28	SEP	2000	661.2	J-Field
28	SEP	2000	661.6	J-Field
3	OCT	2000	663.1	J-Field
3	OCT	2000	663.4	J-Field
3	OCT	2000	663.5	J-Field
3	OCT	2000	663.6	J-Field
3	OCT	2000	663.7	J-Field
3	OCT	2000	663.8	J-Field

TABLE A.5 continued

YEAR: **2000**
LOCATION: **CLUSTER 3**

DAY	MONTH	YEAR	FILE	LOCATION
3	MAY	2000	604.4	Cluster 3
3	AUG	2000	602.3	Cluster 3
3	AUG	2000	602.7	Cluster 3
3	AUG	2000	604.1	Cluster 3
3	AUG	2000	608.2	Cluster 3
3	AUG	2000	608.5	Cluster 3
3	AUG	2000	608.6	Cluster 3
3	AUG	2000	608.7	Cluster 3
3	AUG	2000	610.1	Cluster 3
3	AUG	2000	610.2	Cluster 3
28	SEP	2000	660.3	Cluster 3
28	SEP	2000	660.7	Cluster 3
28	SEP	2000	661.1	Cluster 3
28	SEP	2000	661.1	Cluster 3
28	SEP	2000	661.1	Cluster 3
28	SEP	2000	661.3	Cluster 3
28	SEP	2000	661.7	Cluster 3
28	SEP	2000	661.9	Cluster 3

YEAR: **2000**
LOCATION: **EAST SHORE**

DAY	MONTH	YEAR	FILE	LOCATION
2	MAY	2000	608.3	East Shore
2	AUG	2000	602.5	East Shore
2	AUG	2000	604.3	East Shore
2	AUG	2000	604.5	East Shore
2	AUG	2000	604.6	East Shore
2	AUG	2000	608.1	East Shore
2	AUG	2000	608.4	East Shore
20	AUG	2000	602.4	East Shore
27	SEP	2000	660.4	East Shore
27	SEP	2000	660.5	East Shore
27	SEP	2000	661.1	East Shore
27	SEP	2000	661.1	East Shore
27	SEP	2000	661.2	East Shore
27	SEP	2000	661.4	East Shore
27	SEP	2000	661.5	East Shore
27	SEP	2000	662.1	East Shore

TABLE A.5 continued

YEAR: **1999**

LOCATION: **J - FIELD**

DAY	MONTH	YEAR	FILE	LOCATION
11	MAR	1999	127.1	J-Field
11	MAR	1999	127.2	J-Field
11	MAR	1999	127.4	J-Field
11	MAR	1999	127.5	J-Field
11	MAR	1999	127.7	J-Field
11	MAR	1999	132.1	J-Field
11	MAR	1999	132.2	J-Field
11	MAR	1999	132.4	J-Field
11	MAR	1999	132.5	J-Field
11	MAR	1999	132.7	J-Field
11	MAR	1999	134.1	J-Field
11	MAR	1999	134.2	J-Field
11	MAR	1999	134.4	J-Field
11	MAR	1999	134.5	J-Field
11	MAR	1999	134.7	J-Field
11	MAR	1999	135.2	J-Field
11	MAR	1999	135.4	J-Field
11	MAR	1999	135.5	J-Field
11	MAR	1999	135.7	J-Field
11	MAR	1999	137.1	J-Field
11	MAR	1999	137.2	J-Field
11	MAR	1999	137.4	J-Field
11	MAR	1999	137.5	J-Field
11	MAR	1999	140.2	J-Field
11	MAR	1999	140.4	J-Field
13	MAR	1999	151.1	J-Field
20	MAR	1999	138.1	J-Field
23	MAR	1999	138.2	J-Field
23	MAR	1999	138.4	J-Field
23	MAR	1999	138.5	J-Field
23	MAR	1999	140.5	J-Field
23	MAR	1999	140.7	J-Field
13	APR	1999	151.2	J-Field
13	APR	1999	151.4	J-Field
13	APR	1999	151.5	J-Field
13	APR	1999	151.7	J-Field
13	APR	1999	153.1	J-Field
13	APR	1999	153.2	J-Field
13	APR	1999	153.4	J-Field
13	APR	1999	153.5	J-Field
13	APR	1999	153.7	J-Field
13	APR	1999	154.1	J-Field

DAY	MONTH	YEAR	FILE	LOCATION
13	APR	1999	154.2	J-Field
13	APR	1999	154.4	J-Field
13	APR	1999	154.5	J-Field
13	APR	1999	154.7	J-Field
13	APR	1999	156.2	J-Field
13	APR	1999	156.4	J-Field
13	APR	1999	156.5	J-Field
13	APR	1999	156.7	J-Field
13	APR	1999	157.1	J-Field
13	APR	1999	157.2	J-Field
13	APR	1999	157.4	J-Field
13	APR	1999	157.5	J-Field
13	APR	1999	157.7	J-Field
14	APR	1999	158.4	J-Field
14	APR	1999	158.5	J-Field
14	APR	1999	158.7	J-Field
14	APR	1999	158.8	J-Field
27	APR	1999	141.2	J-Field
27	APR	1999	141.4	J-Field
27	APR	1999	141.5	J-Field
27	APR	1999	141.7	J-Field
27	APR	1999	143.2	J-Field
27	APR	1999	143.4	J-Field
27	APR	1999	143.5	J-Field
27	APR	1999	145.2	J-Field
27	APR	1999	148.2	J-Field
27	APR	1999	148.3	J-Field
27	APR	1999	148.5	J-Field
27	APR	1999	148.6	J-Field
27	APR	1999	150.2	J-Field
27	APR	1999	150.4	J-Field
27	APR	1999	150.5	J-Field
27	APR	1999	150.7	J-Field
28	APR	1999	141.8	J-Field
28	APR	1999	143.8	J-Field
28	APR	1999	148.8	J-Field
28	APR	1999	150.8	J-Field
19	JUN	1999	143.7	J-Field
19	JUN	1999	210.1	J-Field
19	JUN	1999	210.2	J-Field
19	JUN	1999	210.4	J-Field
19	JUN	1999	210.5	J-Field

TABLE A.5 continued

YEAR: **1999**

LOCATION: **J - FIELD** continued

DAY	MONTH	YEAR	FILE	LOCATION
19	JUN	1999	210.7	J-Field
19	JUN	1999	213.2	J-Field
19	JUN	1999	213.4	J-Field
19	JUN	1999	213.5	J-Field
28	JUN	1999	218.2	J-Field
28	JUN	1999	218.4	J-Field
28	JUN	1999	218.5	J-Field
28	JUN	1999	218.7	J-Field
28	JUN	1999	219.1	J-Field
28	JUN	1999	219.2	J-Field
6	AUG	1999	239.1	J-Field
6	AUG	1999	239.5	J-Field
6	AUG	1999	239.7	J-Field
6	AUG	1999	242.1	J-Field
6	AUG	1999	242.7	J-Field
6	AUG	1999	243.4	J-Field
6	AUG	1999	243.5	J-Field
6	AUG	1999	247.4	J-Field
10	SEP	1999	261.2	J-Field
10	SEP	1999	261.4	J-Field
10	SEP	1999	261.5	J-Field
10	SEP	1999	261.7	J-Field
10	SEP	1999	261.8	J-Field
10	SEP	1999	262.2	J-Field
10	SEP	1999	262.4	J-Field
10	SEP	1999	262.5	J-Field
16	OCT	1999	293.2	J-Field
16	OCT	1999	293.4	J-Field
16	OCT	1999	293.5	J-Field
16	OCT	1999	293.7	J-Field
16	OCT	1999	294.2	J-Field
16	OCT	1999	294.4	J-Field
16	OCT	1999	294.5	J-Field
16	OCT	1999	294.7	J-Field
16	OCT	1999	296.2	J-Field
16	OCT	1999	296.4	J-Field
16	OCT	1999	296.5	J-Field
16	OCT	1999	296.7	J-Field
16	OCT	1999	300.2	J-Field
16	OCT	1999	300.4	J-Field

DAY	MONTH	YEAR	FILE	LOCATION
16	OCT	1999	300.5	J-Field
16	OCT	1999	300.7	J-Field
16	OCT	1999	301.2	J-Field
16	OCT	1999	301.4	J-Field
16	OCT	1999	301.5	J-Field
16	OCT	1999	301.7	J-Field

TABLE A.5 continued

YEAR: **1999**
LOCATION: **CHURCHVILLE**

DAY	MONTH	YEAR	FILE	LOC.
24	JUN	1999	215.1	Churchville
24	JUN	1999	215.2	Churchville
24	JUN	1999	215.4	Churchville
24	JUN	1999	215.5	Churchville
24	JUN	1999	215.7	Churchville
24	JUN	1999	219.4	Churchville
24	JUN	1999	219.5	Churchville
24	JUN	1999	219.7	Churchville
3	AUG	1999	243.1	Churchville
3	AUG	1999	242.2	Churchville
3	AUG	1999	239.4	Churchville
3	AUG	1999	243.2	Churchville
3	AUG	1999	242.5	Churchville
3	AUG	1999	239.2	Churchville
3	AUG	1999	242.4	Churchville
3	AUG	1999	243.7	Churchville
24	SEP	1999	281.2	Churchville
24	SEP	1999	290.2	Churchville
24	SEP	1999	290.5	Churchville
24	SEP	1999	289.7	Churchville

YEAR: **1999**
LOCATION: **CLUSTER 3**

DAY	MONTH	YEAR	FILE	LOC.
17	AUG	1999	247.1	Cluster 3
17	AUG	1999	247.2	Cluster 3
17	AUG	1999	245.1	Cluster 3
17	AUG	1999	245.2	Cluster 3
17	AUG	1999	245.4	Cluster 3
17	AUG	1999	245.5	Cluster 3
17	AUG	1999	245.7	Cluster 3
17	AUG	1999	247.5	Cluster 3
14	SEP	1999	265.2	Cluster 3
14	SEP	1999	265.7	Cluster 3
14	SEP	1999	266.4	Cluster 3
14	SEP	1999	266.5	Cluster 3
14	SEP	1999	266.7	Cluster 3
14	SEP	1999	266.8	Cluster 3
14	SEP	1999	279.1	Cluster 3
14	SEP	1999	263.4	Cluster 3
13	OCT	1999	304.2	Cluster 3
13	OCT	1999	304.4	Cluster 3
13	OCT	1999	304.5	Cluster 3
13	OCT	1999	304.7	Cluster 3
13	OCT	1999	302.2	Cluster 3
13	OCT	1999	302.4	Cluster 3
13	OCT	1999	302.5	Cluster 3
13	OCT	1999	302.7	Cluster 3

TABLE A.5 continued

YEAR: **1999**
LOCATION: **YOUTH CENTER**

DAY	MONTH	YEAR	FILE	LOCATION
23	JUL	1999	233.1	Youth Center
23	JUL	1999	237.6	Youth Center
23	JUL	1999	230.2	Youth Center
14	SEP	1999	279.5	Youth Center
14	SEP	1999	265.4	Youth Center
14	SEP	1999	263.7	Youth Center

YEAR: **1999**
LOCATION: **CLUSTER 13**

DAY	MONTH	YEAR	FILE	LOCATION
23	JUL	1999	233.2	Cluster 13
23	JUL	1999	233.7	Cluster 13
23	JUL	1999	228.2	Cluster 13
14	SEP	1999	265.5	Cluster 13
14	SEP	1999	266.2	Cluster 13
14	SEP	1999	263.5	Cluster 13

YEAR: **1999**
LOCATION: **OTTER CREEK DRIVE**

DAY	MONTH	YEAR	FILE	LOCATION
23	JUL	1999	232.7	Otter Creek Drive
23	JUL	1999	232.4	Otter Creek Drive
27	JUL	1999	235.8	Otter Creek Drive
25	SEP	1999	285.4	Otter Creek Drive
25	SEP	1999	287.5	Otter Creek Drive
25	SEP	1999	291.7	Otter Creek Drive

YEAR: **1999**
LOCATION: **LOHR'S ORCHARD**

DAY	MONTH	YEAR	FILE	LOCATION
27	JUL	1999	237.5	Lohr's Orchard
27	JUL	1999	237.8	Lohr's Orchard
27	JUL	1999	228.4	Lohr's Orchard
14	SEP	1999	279.4	Lohr's Orchard
14	SEP	1999	279.7	Lohr's Orchard
14	SEP	1999	263.8	Lohr's Orchard

YEAR: **1999**
LOCATION: **CONOWINGO ORCHARD**

DAY	MONTH	YEAR	FILE	LOCATION
27	JUL	1999	235.5	Conowingo Orchard
27	JUL	1999	235.7	Conowingo Orchard
27	JUL	1999	228.1	Conowingo Orchard
24	SEP	1999	281.5	Conowingo Orchard
24	SEP	1999	281.7	Conowingo Orchard
24	SEP	1999	289.5	Conowingo Orchard

YEAR: **1999**
LOCATION: **JONES FARM**

DAY	MONTH	YEAR	FILE	LOCATION
23	JUL	1999	233.5	Jones Farm
23	JUL	1999	230.4	Jones Farm
27	JUL	1999	237.2	Jones Farm
14	SEP	1999	265.8	Jones Farm
14	SEP	1999	279.2	Jones Farm
14	SEP	1999	263.2	Jones Farm

YEAR: **1999**
LOCATION: **TOWER HILL FARM**

DAY	MONTH	YEAR	FILE	LOCATION
26	JUL	1999	237.3	Tower Hill Farm
26	JUL	1999	230.5	Tower Hill Farm
27	JUL	1999	238.2	Tower Hill Farm
24	SEP	1999	290.4	Tower Hill Farm
24	SEP	1999	290.7	Tower Hill Farm
24	SEP	1999	289.8	Tower Hill Farm

YEAR: **1999**
LOCATION: **SHAWSVILLE**

DAY	MONTH	YEAR	FILE	LOCATION
27	JUL	1999	232.5	Shawsville
27	JUL	1999	235.4	Shawsville
27	JUL	1999	230.7	Shawsville
24	SEP	1999	281.1	Shawsville
24	SEP	1999	281.4	Shawsville

YEAR: **1999**
LOCATION: **RUMSEY ISLAND**

DAY	MONTH	YEAR	FILE	LOCATION
23	JUL	1999	233.4	Rumsey Island
23	JUL	1999	228.5	Rumsey Island
27	JUL	1999	238.8	Rumsey Island
25	SEP	1999	284.2	Rumsey Island
25	SEP	1999	287.2	Rumsey Island
25	SEP	1999	291.2	Rumsey Island

TABLE A.5 continued

YEAR: **1999**

LOCATION: **SILVER LAKE DRIVE**

DAY	MONTH	YEAR	FILE	LOCATION
26	JUL	1999	228.7	Silver Lake Drive
27	JUL	1999	238.6	Silver Lake Drive
25	SEP	1999	285.8	Silver Lake Drive
25	SEP	1999	287.4	Silver Lake Drive
25	SEP	1999	291.4	Silver Lake Drive

YEAR: **1999**

LOCATION: **CYLBURN ARBORETUM**

DAY	MONTH	YEAR	FILE	LOCATION
27	JUL	1999	238.3	Cylburn Arboretum
27	JUL	1999	238.5	Cylburn Arboretum
27	JUL	1999	230.8	Cylburn Arboretum
25	SEP	1999	285.5	Cylburn Arboretum
25	SEP	1999	285.7	Cylburn Arboretum
25	SEP	1999	291.5	Cylburn Arboretum

TABLE A.5 continued

YEAR: **1998**
LOCATION: **O - FIELD**

DAY	MONTH	YEAR	FILE	LOCATION
2	JUN	1998	2269.4	O-Field
2	JUN	1998	2272.4	O-Field
2	JUN	1998	2273.3	O-Field
2	JUN	1998	2270.8	O-Field
2	JUN	1998	2272.6	O-Field
2	JUN	1998	2270.5	O-Field
2	JUN	1998	2270.2	O-Field
2	JUN	1998	2269.7	O-Field
2	JUN	1998	2269.6	O-Field
2	JUN	1998	2270.6	O-Field
2	JUN	1998	2272.3	O-Field
15	JUL	1998	2357.3	O-Field
15	JUL	1998	2356.6	O-Field
15	JUL	1998	2356.3	O-Field
15	JUL	1998	2355.8	O-Field
15	JUL	1998	2357.5	O-Field
15	JUL	1998	2357.1	O-Field
15	JUL	1998	2357.8	O-Field
15	JUL	1998	2356.8	O-Field
15	JUL	1998	2357.6	O-Field
15	JUL	1998	2356.1	O-Field
7	AUG	1998	2435.6	O-Field
7	AUG	1998	2433.8	O-Field
7	AUG	1998	2436.4	O-Field
7	AUG	1998	2436.6	O-Field
7	AUG	1998	2435.2	O-Field
7	AUG	1998	2438.7	O-Field
7	AUG	1998	2435.4	O-Field
7	AUG	1998	2438.5	O-Field
7	AUG	1998	2436.8	O-Field
7	AUG	1998	2433.6	O-Field
3	SEP	1998	2575.4	O-Field
3	SEP	1998	2575.1	O-Field
3	SEP	1998	2575.2	O-Field
3	SEP	1998	2574.1	O-Field
3	SEP	1998	2575.6	O-Field
3	SEP	1998	2575.7	O-Field
29	SEP	1998	2508.5	O-Field
29	SEP	1998	2505.6	O-Field
29	SEP	1998	2506.3	O-Field
29	SEP	1998	2506.5	O-Field
29	SEP	1998	2508.2	O-Field
29	SEP	1998	2508.3	O-Field
29	SEP	1998	2506.2	O-Field

DAY	MONTH	YEAR	FILE	LOCATION
29	SEP	1998	2505.1	O-Field
29	SEP	1998	2505.3	O-Field
29	SEP	1998	2506.8	O-Field
29	SEP	1998	2505.5	O-Field

TABLE A.5 continued

YEAR: **1998**
LOCATION: **YOUTH CENTER**

DAY	MONTH	YEAR	FILE	LOCATION
9	JUN	1998	2298.6	Youth Center
9	JUN	1998	2301.3	Youth Center
13	AUG	1998	2564.1	Youth Center
13	AUG	1998	2564.2	Youth Center
13	AUG	1998	2565.1	Youth Center
13	AUG	1998	2566.7	Youth Center
22	OCT	1998	2579.1	Youth Center
22	OCT	1998	2579.2	Youth Center
22	OCT	1998	2576.2	Youth Center
22	OCT	1998	2576.6	Youth Center

YEAR: **1998**
LOCATION: **OTTER CREEK DRIVE**

DAY	MONTH	YEAR	FILE	LOCATION
9	JUN	1998	2303.5	Otter Creek Drive
9	JUN	1998	2301.2	Otter Creek Drive
9	JUN	1998	2298.5	Otter Creek Drive
10	AUG	1998	2518.5	Otter Creek Drive
10	AUG	1998	2518.3	Otter Creek Drive
22	OCT	1998	2579.7	Otter Creek Drive
22	OCT	1998	2577.1	Otter Creek Drive
22	OCT	1998	2576.1	Otter Creek Drive

YEAR: **1998**
LOCATION: **CONOWINGO ORCHARD**

DAY	MONTH	YEAR	FILE	LOCATION
9	JUN	1998	2303.3	Conowingo Orchard
9	JUN	1998	2303.8	Conowingo Orchard
9	JUN	1998	2300.3	Conowingo Orchard
10	AUG	1998	2518.8	Conowingo Orchard
10	AUG	1998	2519.6	Conowingo Orchard
29	OCT	1998	2587.1	Conowingo Orchard
29	OCT	1998	2587.2	Conowingo Orchard

YEAR: **1998**
LOCATION: **CLUSTER 13**

DAY	MONTH	YEAR	FILE	LOCATION
9	JUN	1998	2300.6	Cluster 13
9	JUN	1998	2300.4	Cluster 13
11	AUG	1998	2520.8	Cluster 13
11	AUG	1998	2521.2	Cluster 13
11	AUG	1998	2557.4	Cluster 13

YEAR: **1998**
LOCATION: **ABERDEEN POST**

DAY	MONTH	YEAR	FILE	LOCATION
9	JUN	1998	2301.6	Aberdeen Post
9	JUN	1998	2303.2	Aberdeen Post
10	AUG	1998	2519.2	Aberdeen Post
10	AUG	1998	2519.3	Aberdeen Post
10	AUG	1998	2518.2	Aberdeen Post

YEAR: **1998**
LOCATION: **LOHR'S ORCHARD**

DAY	MONTH	YEAR	FILE	LOCATION
9	JUN	1998	2306.8	Lohr's Orchard
9	JUN	1998	2300.7	Lohr's Orchard
9	JUN	1998	2301.8	Lohr's Orchard
10	AUG	1998	2518.6	Lohr's Orchard
27	OCT	1998	2581.2	Lohr's Orchard
27	OCT	1998	2581.4	Lohr's Orchard

YEAR: **1998**
LOCATION: **JONES FARM**

DAY	MONTH	YEAR	FILE	LOCATION
7	JUL	1998	2331.3	Jones Farm
7	JUL	1998	2331.6	Jones Farm
7	JUL	1998	2343.2	Jones Farm
13	AUG	1998	2564.4	Jones Farm
13	AUG	1998	2564.6	Jones Farm
13	AUG	1998	2565.2	Jones Farm
22	OCT	1998	2579.4	Jones Farm
22	OCT	1998	2579.6	Jones Farm
22	OCT	1998	2576.4	Jones Farm

TABLE A.5 continued

YEAR: **1998**
LOCATION: **TOWER HILL FARM**

DAY	MONTH	YEAR	FILE	LOCATION
7	JUL	1998	2331.8	Tower Hill Farm
7	JUL	1998	2344.8	Tower Hill Farm
13	AUG	1998	2566.2	Tower Hill Farm
13	AUG	1998	2566.4	Tower Hill Farm
13	AUG	1998	2565.4	Tower Hill Farm
29	OCT	1998	2587.4	Tower Hill Farm
29	OCT	1998	2587.6	Tower Hill Farm

YEAR: **1998**
LOCATION: **SHAWSVILLE**

DAY	MONTH	YEAR	FILE	LOCATION
7	JUL	1998	2343.5	Shawsville
7	JUL	1998	2331.5	Shawsville
7	JUL	1998	2331.2	Shawsville
13	AUG	1998	2566.6	Shawsville
13	AUG	1998	2565.6	Shawsville
29	OCT	1998	2587.7	Shawsville
29	OCT	1998	2586.1	Shawsville

YEAR: **1998**
LOCATION: **WESTWOOD ROAD**

DAY	MONTH	YEAR	FILE	LOCATION
7	JUL	1998	2330.5	Westwood Road
7	JUL	1998	2330.4	Westwood Road
7	JUL	1998	2341.4	Westwood Road
11	AUG	1998	2520.5	Westwood Road
11	AUG	1998	2520.6	Westwood Road
11	AUG	1998	2521.5	Westwood Road
29	AUG	1998	2505.8	Westwood Road
29	AUG	1998	2504.6	Westwood Road
29	AUG	1998	2506.6	Westwood Road

YEAR: **1998**
LOCATION: **GRACE'S QUARTERS**

DAY	MONTH	YEAR	FILE	LOCATION
18	JUN	1998	2304.6	Grace's Quarters
18	JUN	1998	2306.3	Grace's Quarters
18	JUN	1998	2304.3	Grace's Quarters
11	AUG	1998	2520.2	Grace's Quarters
11	AUG	1998	2520.3	Grace's Quarters
11	AUG	1998	2557.2	Grace's Quarters
22	OCT	1998	2517.5	Grace's Quarters
22	OCT	1998	2517.6	Grace's Quarters
22	OCT	1998	2577.7	Grace's Quarters

YEAR: **1998**
LOCATION: **RUMSEY MANSION**

DAY	MONTH	YEAR	FILE	LOCATION
18	JUN	1998	2309.2	Rumsey Mansion
18	JUN	1998	2307.4	Rumsey Mansion
18	JUN	1998	2307.3	Rumsey Mansion
11	AUG	1998	2521.2	Rumsey Mansion
11	AUG	1998	2521.3	Rumsey Mansion
11	AUG	1998	2557.1	Rumsey Mansion
22	OCT	1998	2577.1	Rumsey Mansion
22	OCT	1998	2577.4	Rumsey Mansion
22	OCT	1998	2577.6	Rumsey Mansion

YEAR: **1998**
LOCATION: **CARROLL ISLAND**

DAY	MONTH	YEAR	FILE	LOCATION
18	JUN	1998	2307.8	Carroll Island
18	JUN	1998	2304.4	Carroll Island
18	JUN	1998	2309.3	Carroll Island
7	AUG	1998	2438.3	Carroll Island
7	AUG	1998	2438.1	Carroll Island
7	AUG	1998	2433.4	Carroll Island
10	AUG	1998	2519.8	Carroll Island
10	AUG	1998	2521.8	Carroll Island
10	AUG	1998	2519.5	Carroll Island
22	OCT	1998	2517.3	Carroll Island
22	OCT	1998	2517.8	Carroll Island

TABLE A.5 continued

YEAR: **1998**
LOCATION: **SILVER LAKE DRIVE**

DAY	MONTH	YEAR	FILE	LOCATION
18	JUN	1998	2307.7	Silver Lake Drive
18	JUN	1998	2307.6	Silver Lake Drive
18	JUN	1998	2306.6	Silver Lake Drive
14	AUG	1998	2568.1	Silver Lake Drive
14	AUG	1998	2568.2	Silver Lake Drive
14	AUG	1998	2571.1	Silver Lake Drive
29	OCT	1998	2586.2	Silver Lake Drive
29	OCT	1998	2586.4	Silver Lake Drive

YEAR: **1998**
LOCATION: **CYLBURN ARBORETUM**

DAY	MONTH	YEAR	FILE	LOCATION
18	JUN	1998	2306.2	Cylburn Arboretum
18	JUN	1998	2304.7	Cylburn Arboretum
18	JUN	1998	2306.5	Cylburn Arboretum
14	AUG	1998	2568.4	Cylburn Arboretum
14	AUG	1998	2568.6	Cylburn Arboretum
14	AUG	1998	2568.7	Cylburn Arboretum
29	OCT	1998	2586.6	Cylburn Arboretum
29	OCT	1998	2586.7	Cylburn Arboretum

YEAR: **1998**
LOCATION: **J - FIELD**

DAY	MONTH	YEAR	FILE	LOCATION
27	JUN	1998	2334.2	J-Field
27	JUN	1998	2334.3	J-Field
27	JUN	1998	2334.5	J-Field
27	JUN	1998	2334.6	J-Field
27	JUN	1998	2334.8	J-Field
27	JUN	1998	2336.3	J-Field
27	JUN	1998	2336.6	J-Field
27	JUN	1998	2336.8	J-Field
27	JUN	1998	2337.2	J-Field
27	JUN	1998	2337.3	J-Field
27	JUN	1998	2337.5	J-Field
27	JUN	1998	2337.6	J-Field
27	JUN	1998	2337.8	J-Field
12	JUL	1998	2347.1	J-Field
12	JUL	1998	2347.3	J-Field
12	JUL	1998	2347.4	J-Field
12	JUL	1998	2347.6	J-Field
12	JUL	1998	2347.8	J-Field
12	JUL	1998	2349.3	J-Field
12	JUL	1998	2349.5	J-Field
12	JUL	1998	2349.7	J-Field
12	JUL	1998	2350.3	J-Field
12	JUL	1998	2350.4	J-Field
12	JUL	1998	2350.6	J-Field
12	JUL	1998	2350.8	J-Field
12	JUL	1998	2355.3	J-Field
12	JUL	1998	2355.6	J-Field

DAY	MONTH	YEAR	FILE	LOCATION
8	AUG	1998	2436.2	J-Field
8	AUG	1998	2440.1	J-Field
8	AUG	1998	2440.3	J-Field
8	AUG	1998	2440.5	J-Field
8	AUG	1998	2440.7	J-Field
8	AUG	1998	2441.3	J-Field
8	AUG	1998	2441.5	J-Field
8	AUG	1998	2441.7	J-Field
8	AUG	1998	2442.1	J-Field
8	AUG	1998	2442.5	J-Field
8	AUG	1998	2442.7	J-Field
8	AUG	1998	2444.1	J-Field
8	AUG	1998	2444.3	J-Field
8	AUG	1998	2444.5	J-Field
11	AUG	1998	2557.6	J-Field
11	AUG	1998	2557.7	J-Field
11	AUG	1998	2559.1	J-Field
29	AUG	1998	2570.2	J-Field
29	AUG	1998	2570.6	J-Field
29	AUG	1998	2570.7	J-Field
29	AUG	1998	2571.2	J-Field
29	AUG	1998	2571.6	J-Field
29	AUG	1998	2571.7	J-Field
29	AUG	1998	2572.1	J-Field
29	AUG	1998	2572.2	J-Field
29	AUG	1998	2572.4	J-Field
29	AUG	1998	2572.6	J-Field

TABLE A.5 continued

YEAR: **1998**

LOCATION: **J - FIELD** continued

DAY	MONTH	YEAR	FILE	LOCATION
29	AUG	1998	2569.1	J-Field
29	AUG	1998	2569.2	J-Field
29	AUG	1998	2569.4	J-Field
29	AUG	1998	2569.6	J-Field
29	AUG	1998	2569.7	J-Field
29	AUG	1998	2570.1	J-Field
12	OCT	1998	2512.2	J-Field
12	OCT	1998	2512.3	J-Field
12	OCT	1998	2513.2	J-Field
12	OCT	1998	2513.3	J-Field
12	OCT	1998	2513.5	J-Field
12	OCT	1998	2513.6	J-Field
12	OCT	1998	2513.8	J-Field
12	OCT	1998	2515.2	J-Field
12	OCT	1998	2515.3	J-Field
12	OCT	1998	2515.5	J-Field
12	OCT	1998	2515.6	J-Field
12	OCT	1998	2515.8	J-Field
12	OCT	1998	2516.2	J-Field
12	OCT	1998	2516.3	J-Field
12	OCT	1998	2516.5	J-Field
12	OCT	1998	2516.6	J-Field
12	OCT	1998	2516.8	J-Field
12	OCT	1998	2517.2	J-Field

YEAR: **1998**

LOCATION: **D - FIELD**

DAY	MONTH	YEAR	FILE	LOCATION
3	JUN	1998	2278.6	D-Field
3	JUN	1998	2273.6	D-Field
3	JUN	1998	2276.5	D-Field
3	JUN	1998	2277.2	D-Field
3	JUN	1998	2273.5	D-Field
3	JUN	1998	2276.8	D-Field
3	JUN	1998	2277.5	D-Field
3	JUN	1998	2276.3	D-Field
3	JUN	1998	2770.1	D-Field
3	JUN	1998	2272.3	D-Field
3	JUN	1998	2277.3	D-Field
3	JUN	1998	2273.2	D-Field
3	JUN	1998		D-Field
3	JUN	1998	2273.8	D-Field
3	JUN	1998	2276.2	D-Field
27	JUN	1998	2344.2	D-Field
9	AUG	1998	2448.7	D-Field
9	AUG	1998	2448.3	D-Field
9	AUG	1998	2448.5	D-Field
9	AUG	1998	2446.2	D-Field
9	AUG	1998	2449.3	D-Field
9	AUG	1998	2448.2	D-Field
9	AUG	1998	2449.7	D-Field
9	AUG	1998	2446.7	D-Field
9	AUG	1998	2448.8	D-Field
9	AUG	1998	2449.5	D-Field
9	AUG	1998	2446.3	D-Field
9	AUG	1998	2446.8	D-Field
9	AUG	1998	2449.8	D-Field
12	AUG	1998	2560.7	D-Field
12	AUG	1998	2559.6	D-Field
12	AUG	1998	2560.2	D-Field
12	AUG	1998	2562.4	D-Field
12	AUG	1998	2559.2	D-Field
12	AUG	1998	2560.4	D-Field
12	AUG	1998	2562.2	D-Field
12	AUG	1998	2562.6	D-Field
12	AUG	1998	2560.6	D-Field
12	AUG	1998	2559.7	D-Field
12	AUG	1998	2560.1	D-Field
12	AUG	1998	2562.7	D-Field
12	AUG	1998	2559.4	D-Field
30	SEP	1998	2510.8	D-Field

TABLE A.5 continued

YEAR: **1998**
LOCATION: **D - FIELD** continued

DAY	MONTH	YEAR	FILE	LOCATION
30	SEP	1998	2508.6	D-Field
30	SEP	1998	2508.8	D-Field
30	SEP	1998	2509.2	D-Field
30	SEP	1998	2509.3	D-Field
30	SEP	1998	2509.5	D-Field
30	SEP	1998	2509.6	D-Field
30	SEP	1998	2509.8	D-Field
30	SEP	1998	2510.2	D-Field
30	SEP	1998	2510.3	D-Field
30	SEP	1998	2510.5	D-Field
30	SEP	1998	2510.6	D-Field
30	SEP	1998	2511.2	D-Field
30	SEP	1998	2511.3	D-Field
30	SEP	1998	2511.5	D-Field
30	SEP	1998	2511.6	D-Field
30	SEP	1998	2512.5	D-Field
30	SEP	1998	2512.6	D-Field

YEAR: **1998**
LOCATION: **CHURCHVILLE**

DAY	MONTH	YEAR	FILE	LOCATION
7	JUL	1998	2330.2	Churchville
7	JUL	1998	2341.3	Churchville
7	JUL	1998	2343.3	Churchville
7	JUL	1998	2341.8	Churchville
7	JUL	1998	2343.6	Churchville
7	JUL	1998	2341.6	Churchville
13	AUG	1998	2563.7	Churchville
13	AUG	1998	2563.6	Churchville
13	AUG	1998	2563.2	Churchville
13	AUG	1998	2563.1	Churchville
13	AUG	1998	2565.7	Churchville
13	AUG	1998	2563.4	Churchville
13	AUG	1998	2563.8	Churchville
13	AUG	1998	2564.7	Churchville
27	OCT	1998	2583.7	Churchville
27	OCT	1998	2583.6	Churchville
27	OCT	1998	2583.2	Churchville
27	OCT	1998	2583.1	Churchville
27	OCT	1998	2581.7	Churchville
27	OCT	1998	2583.4	Churchville
27	OCT	1998	2581.6	Churchville

TABLE A.5 continued

YEAR: **1997**

LOCATION: **J - FIELD**

DAY	MONTH	YEAR	FILE	LOCATION
11	MAY	1997	1931.4	J-Field
11	MAY	1997	1931.5	J-Field
11	MAY	1997	1993.0	J-Field
6	JUN	1997	1946.5	J-Field
6	JUN	1997	1946.7	J-Field
6	JUN	1997	1946.8	J-Field
19	JUN	1997	1956.1	J-Field
19	JUN	1997	1956.2	J-Field
19	JUN	1997	1956.4	J-Field
15	JUL	1997	1988.1	J-Field
15	JUL	1997	1988.2	J-Field
15	JUL	1997	1988.4	J-Field
15	JUL	1997	1988.5	J-Field
15	JUL	1997	1988.7	J-Field
31	JUL	1997	2032.2	J-Field
31	JUL	1997	2032.4	J-Field
31	JUL	1997	2032.6	J-Field
31	JUL	1997	2032.8	J-Field
31	JUL	1997	2034.2	J-Field
31	JUL	1997	2034.4	J-Field
15	SEP	1997	2114.2	J-Field
15	SEP	1997	2114.3	J-Field
15	SEP	1997	2114.5	J-Field
15	SEP	1997	2114.6	J-Field
15	SEP	1997	2116.2	J-Field
15	SEP	1997	2116.3	J-Field
15	SEP	1997	2116.5	J-Field
15	SEP	1997	2116.6	J-Field
15	SEP	1997	2118.1	J-Field
15	SEP	1997	2118.2	J-Field
15	SEP	1997	2118.4	J-Field
15	SEP	1997	2118.5	J-Field
23	OCT	1997	2143.1	J-Field
23	OCT	1997	2143.2	J-Field
23	OCT	1997	2143.4	J-Field
23	OCT	1997	2143.5	J-Field
23	OCT	1997	2143.7	J-Field
23	OCT	1997	2145.1	J-Field
23	OCT	1997	2145.3	J-Field
23	OCT	1997	2145.4	J-Field
23	OCT	1997	2145.6	J-Field
23	OCT	1997	2145.7	J-Field

TABLE A.5 continued

YEAR: **1997**

LOCATION: **O - FIELD**

DAY	MONTH	YEAR	FILE	LOCATION
11	MAY	1997	1931.2	O-Field
11	MAY	1997	1933.0	O-Field
6	JUN	1997	1946.1	O-Field
6	JUN	1997	1946.2	O-Field
6	JUN	1997	1946.4	O-Field
19	JUN	1997	1956.5	O-Field
19	JUN	1997	1956.7	O-Field
19	JUN	1997	1956.8	O-Field
15	JUL	1997	1981.1	O-Field
15	JUL	1997	1981.2	O-Field
15	JUL	1997	1981.4	O-Field
15	JUL	1997	1981.5	O-Field
15	JUL	1997	1981.7	O-Field
31	JUL	1997	2034.6	O-Field
31	JUL	1997	2034.7	O-Field
31	JUL	1997	2035.2	O-Field
31	JUL	1997	2035.4	O-Field
31	JUL	1997	2035.6	O-Field
31	JUL	1997	2035.8	O-Field
31	JUL	1997	2037.4	O-Field
31	JUL	1997	2037.6	O-Field
31	JUL	1997	2037.8	O-Field
26	AUG	1997	2064.2	O-Field
26	AUG	1997	2064.6	O-Field
26	AUG	1997	2067.4	O-Field
26	AUG	1997	2067.6	O-Field
26	AUG	1997	2067.8	O-Field
19	SEP	1997	2120.3	O-Field
19	SEP	1997	2120.5	O-Field
19	SEP	1997	2120.6	O-Field
19	SEP	1997	2121.1	O-Field
19	SEP	1997	2121.2	O-Field
19	SEP	1997	2121.4	O-Field
19	SEP	1997	2121.5	O-Field
19	SEP	1997	2121.7	O-Field
19	SEP	1997	2118.5	O-Field
29	OCT	1997	2146.1	O-Field
29	OCT	1997	2146.4	O-Field
29	OCT	1997	2146.6	O-Field
29	OCT	1997	2146.7	O-Field
29	OCT	1997	2148.1	O-Field
29	OCT	1997	2148.3	O-Field
29	OCT	1997	2148.4	O-Field
29	OCT	1997	2149.2	O-Field
29	OCT	1997	2149.3	O-Field
29	OCT	1997	2149.5	O-Field

TABLE A.5 continued

YEAR: **1997**

LOCATION: **BUSH RIVER**

DAY	MONTH	YEAR	FILE	LOCATION
7	MAY	1997	1927.1	Bush River
7	MAY	1997	1927.2	Bush River
7	MAY	1997	1927.4	Bush River
7	MAY	1997	1927.5	Bush River
7	MAY	1997	1927.7	Bush River
7	MAY	1997	1927.8	Bush River
7	MAY	1997	1928.1	Bush River
7	MAY	1997	1928.4	Bush River
10	MAY	1997	1928.5	Bush River
10	MAY	1997	1928.7	Bush River
10	MAY	1997	1928.8	Bush River
10	MAY	1997	1929.1	Bush River
10	MAY	1997	1929.2	Bush River
10	MAY	1997	1929.4	Bush River
10	MAY	1997	1929.5	Bush River
10	MAY	1997	1929.7	Bush River
19	MAY	1997	1949.1	Bush River
19	MAY	1997	1949.4	Bush River
19	MAY	1997	1949.5	Bush River
19	MAY	1997	1949.8	Bush River
19	MAY	1997	1950.1	Bush River
19	MAY	1997	1950.2	Bush River
19	MAY	1997	1950.4	Bush River
19	MAY	1997	1950.5	Bush River
19	MAY	1997	1950.7	Bush River
19	MAY	1997	1950.8	Bush River
19	MAY	1997	1951.2	Bush River
19	MAY	1997	1951.4	Bush River
19	MAY	1997	1951.5	Bush River
19	MAY	1997	1951.7	Bush River
6	JUN	1997	1943.1	Bush River
6	JUN	1997	1943.2	Bush River
6	JUN	1997	1943.4	Bush River
6	JUN	1997	1943.5	Bush River
6	JUN	1997	1943.7	Bush River
6	JUN	1997	1944.2	Bush River
6	JUN	1997	1944.4	Bush River
6	JUN	1997	1944.5	Bush River
6	JUN	1997	1944.7	Bush River
8	JUN	1997	1945.1	Bush River
8	JUN	1997	1945.2	Bush River
8	JUN	1997	1945.5	Bush River

DAY	MONTH	YEAR	FILE	LOCATION
8	JUN	1997	1945.7	Bush River
8	JUN	1997	1945.8	Bush River
19	JUN	1997	1957.1	Bush River
19	JUN	1997	1957.2	Bush River
19	JUN	1997	1957.5	Bush River
19	JUN	1997	1957.7	Bush River
19	JUN	1997	1957.8	Bush River
19	JUN	1997	1958.1	Bush River
19	JUN	1997	1958.2	Bush River
20	JUN	1997	1958.4	Bush River
20	JUN	1997	1958.5	Bush River
20	JUN	1997	1958.7	Bush River
20	JUN	1997	1958.8	Bush River
20	JUN	1997	1959.3	Bush River
20	JUN	1997	1960.1	Bush River
20	JUN	1997	1960.4	Bush River
20	JUN	1997	1960.6	Bush River
27	JUL	1997	2003.4	Bush River
27	JUL	1997	2003.8	Bush River
27	JUL	1997	2005.3	Bush River
27	JUL	1997	2005.6	Bush River
27	JUL	1997	2005.8	Bush River
27	JUL	1997	2006.2	Bush River
27	JUL	1997	2006.5	Bush River
27	JUL	1997	2006.7	Bush River
27	JUL	1997	2006.8	Bush River
27	JUL	1997	2008.2	Bush River
27	JUL	1997	2008.4	Bush River
27	JUL	1997	2008.6	Bush River
27	JUL	1997	2008.8	Bush River
27	JUL	1997	2009.2	Bush River
27	JUL	1997	2009.4	Bush River
27	JUL	1997	2009.6	Bush River
29	JUL	1997	2011.4	Bush River
29	JUL	1997	2011.6	Bush River
29	JUL	1997	2011.8	Bush River
29	JUL	1997	2012.2	Bush River
29	JUL	1997	2038.2	Bush River
29	JUL	1997	2038.4	Bush River
29	JUL	1997	2038.8	Bush River
29	JUL	1997	2040.2	Bush River
29	JUL	1997	2040.6	Bush River

TABLE A.5 continued

YEAR: **1997**

LOCATION: **BUSH RIVER** continued

DAY	MONTH	YEAR	FILE	LOCATION
29	JUL	1997	2040.8	Bush River
29	JUL	1997	2041.2	Bush River
29	JUL	1997	2041.4	Bush River
19	AUG	1997	2083.2	Bush River
19	AUG	1997	2083.4	Bush River
19	AUG	1997	2083.6	Bush River
19	AUG	1997	2084.2	Bush River
19	AUG	1997	2084.3	Bush River
19	AUG	1997	2084.5	Bush River
19	AUG	1997	2084.7	Bush River
19	AUG	1997	2084.8	Bush River
29	AUG	1997	2069.2	Bush River
29	AUG	1997	2069.3	Bush River
29	AUG	1997	2069.5	Bush River
29	AUG	1997	2070.2	Bush River
29	AUG	1997	2070.3	Bush River
29	AUG	1997	2070.5	Bush River
29	AUG	1997	2070.6	Bush River
29	AUG	1997	2072.2	Bush River
29	AUG	1997	2072.3	Bush River
29	AUG	1997	2072.5	Bush River
29	AUG	1997	2072.6	Bush River
31	AUG	1997	2076.2	Bush River
31	AUG	1997	2076.3	Bush River
31	AUG	1997	2076.5	Bush River
31	AUG	1997	2076.6	Bush River
31	AUG	1997	2078.2	Bush River
31	AUG	1997	2078.3	Bush River
31	AUG	1997	2078.5	Bush River
31	AUG	1997	2078.6	Bush River
31	AUG	1997	2079.2	Bush River
31	AUG	1997	2079.4	Bush River
31	AUG	1997	2079.6	Bush River
7	SEP	1997	2073.3	Bush River
7	SEP	1997	2073.4	Bush River
7	SEP	1997	2073.6	Bush River
7	SEP	1997	2074.2	Bush River
7	SEP	1997	2074.3	Bush River
7	SEP	1997	2074.5	Bush River
7	SEP	1997	2074.6	Bush River
9	OCT	1997	2127.5	Bush River
9	OCT	1997	2127.7	Bush River
9	OCT	1997	2129.1	Bush River
9	OCT	1997	2129.3	Bush River
8	OCT	1997	2133.1	Bush River
8	OCT	1997	2133.2	Bush River
8	OCT	1997	2133.4	Bush River
8	OCT	1997	2133.5	Bush River
8	OCT	1997	2135.1	Bush River
8	OCT	1997	2135.2	Bush River
8	OCT	1997	2135.5	Bush River
8	OCT	1997	2137.1	Bush River
8	OCT	1997	2137.3	Bush River
8	OCT	1997	2137.4	Bush River
8	OCT	1997	2137.6	Bush River
8	OCT	1997	2137.7	Bush River
8	OCT	1997	2138.2	Bush River
8	OCT	1997	2138.3	Bush River
8	OCT	1997	2138.5	Bush River
8	OCT	1997	2138.7	Bush River
8	OCT	1997	2140.2	Bush River
8	OCT	1997	2140.4	Bush River
9	OCT	1997	2129.4	Bush River
9	OCT	1997	2130.1	Bush River
9	OCT	1997	2130.3	Bush River
9	OCT	1997	2130.4	Bush River
9	OCT	1997	2130.5	Bush River
9	OCT	1997	2130.7	Bush River
9	OCT	1997	2132.1	Bush River
9	OCT	1997	2132.3	Bush River
9	OCT	1997	2132.4	Bush River
9	OCT	1997	2132.6	Bush River
31	OCT	1997	2152.7	Bush River
31	OCT	1997	2154.1	Bush River
31	OCT	1997	2154.3	Bush River
31	OCT	1997	2154.6	Bush River
31	OCT	1997	2154.7	Bush River
31	OCT	1997	2155.2	Bush River
31	OCT	1997	2155.3	Bush River
31	OCT	1997	2155.5	Bush River
31	OCT	1997	2155.7	Bush River
31	OCT	1997	2157.3	Bush River
31	OCT	1997	2157.4	Bush River
31	OCT	1997	2158.1	Bush River
31	OCT	1997	2158.3	Bush River
31	OCT	1997	2158.4	Bush River
31	OCT	1997	2158.6	Bush River
31	OCT	1997	2158.7	Bush River

TABLE A.5 continued

YEAR: **1997**
LOCATION: **NATIONAL GUARD ARMORY**

DAY	MONTH	YEAR	FILE	LOCATION
18	MAY	1997	1934.5	N. Guard Armory
18	MAY	1997	1934.7	N. Guard Armory
15	JUN	1997	1953.5	N. Guard Armory
15	JUN	1997	1953.8	N. Guard Armory
20	JUL	1997	1991.1	N. Guard Armory
20	JUL	1997	1991.3	N. Guard Armory
20	JUL	1997	1991.4	N. Guard Armory
12	AUG	1997	2056.2	N. Guard Armory
12	AUG	1997	2056.3	N. Guard Armory
4	OCT	1997	2126.1	N. Guard Armory
4	OCT	1997	2126.2	N. Guard Armory

YEAR: **1997**
LOCATION: **WEST BRANCH CANAL CREEK**

DAY	MONTH	YEAR	FILE	LOCATION
18	MAY	1997	1936.5	W.B. Canal Creek
18	MAY	1997	1936.7	W.B. Canal Creek
15	JUN	1997	1955.5	W.B. Canal Creek
15	JUN	1997	1955.7	W.B. Canal Creek
20	JUL	1997	1991.6	W.B. Canal Creek
20	JUL	1997	1991.7	W.B. Canal Creek
19	AUG	1997	2086.1	W.B. Canal Creek
19	AUG	1997	2086.3	W.B. Canal Creek
19	AUG	1997	2086.5	W.B. Canal Creek
19	AUG	1997	2087.4	W.B. Canal Creek
19	AUG	1997	2087.6	W.B. Canal Creek
19	AUG	1997	2087.8	W.B. Canal Creek
23	AUG	1997	2057.2	W.B. Canal Creek
23	AUG	1997	2057.4	W.B. Canal Creek
23	AUG	1997	2057.6	W.B. Canal Creek
23	AUG	1997	2057.7	W.B. Canal Creek
23	AUG	1997	2058.2	W.B. Canal Creek
23	AUG	1997	2058.3	W.B. Canal Creek
23	AUG	1997	2058.5	W.B. Canal Creek
23	AUG	1997	2058.6	W.B. Canal Creek
4	OCT	1997	2127.1	W.B. Canal Creek
4	OCT	1997	2127.2	W.B. Canal Creek
4	OCT	1997	2127.4	W.B. Canal Creek

YEAR: **1997**
LOCATION: **BEACH POINT**

DAY	MONTH	YEAR	FILE	LOCATION
18	MAY	1997	1938.1	Beach Point
18	MAY	1997	1938.2	Beach Point
15	JUN	1997	1953.1	Beach Point
15	JUN	1997	1953.2	Beach Point
15	JUN	1997	1953.4	Beach Point
20	JUL	1997	1990.6	Beach Point
20	JUL	1997	1990.8	Beach Point
20	JUL	1997	1993.7	Beach Point
25	JUL	1997	1994.6	Beach Point
25	JUL	1997	1994.8	Beach Point
25	JUL	1997	1997.1	Beach Point
25	JUL	1997	1997.4	Beach Point
12	AUG	1997	2056.5	Beach Point
12	AUG	1997	2056.6	Beach Point
4	OCT	1997	2126.4	Beach Point
4	OCT	1997	2126.5	Beach Point
4	OCT	1997	2126.7	Beach Point

YEAR: **1997**
LOCATION: **EAST BRANCH CANAL CREEK**

DAY	MONTH	YEAR	FILE	LOCATION
18	MAY	1997	1936.1	E.B. Canal Creek
18	MAY	1997	1936.4	E.B. Canal Creek
15	JUN	1997	1955.1	E.B. Canal Creek
15	JUN	1997	1955.2	E.B. Canal Creek
15	JUN	1997	1955.4	E.B. Canal Creek
20	JUL	1997	1994.1	E.B. Canal Creek
20	JUL	1997	1994.2	E.B. Canal Creek
20	JUL	1997	1994.4	E.B. Canal Creek
12	AUG	1997	2053.3	E.B. Canal Creek
12	AUG	1997	2053.5	E.B. Canal Creek
12	AUG	1997	2053.6	E.B. Canal Creek
4	OCT	1997	2124.4	E.B. Canal Creek
4	OCT	1997	2124.5	E.B. Canal Creek
4	OCT	1997	2124.7	E.B. Canal Creek

TABLE A.5 continued

YEAR: **1997**
LOCATION: **LAUNDERICK CREEK**

DAY	MONTH	YEAR	FILE	LOCATION
18	MAY	1997	1947.5	Lauderick Creek
18	MAY	1997	1947.7	Lauderick Creek
15	JUN	1997	1952.5	Lauderick Creek
15	JUN	1997	1952.7	Lauderick Creek
15	JUN	1997	1952.8	Lauderick Creek
18	JUL	1997	1990.4	Lauderick Creek
18	JUL	1997	1989.2	Lauderick Creek
18	JUL	1997	1989.4	Lauderick Creek
29	JUL	1997	2012.4	Lauderick Creek
29	JUL	1997	2012.8	Lauderick Creek
12	AUG	1997	2052.2	Lauderick Creek
12	AUG	1997	2052.3	Lauderick Creek
12	AUG	1997	2052.5	Lauderick Creek

YEAR: **1997**
LOCATION: **YOUTH CENTER**

DAY	MONTH	YEAR	FILE	LOCATION
18	MAY	1997	1948.1	Youth Center
18	MAY	1997	1948.2	Youth Center
15	JUN	1997	1952.1	Youth Center
15	JUN	1997	1952.2	Youth Center
15	JUN	1997	1952.4	Youth Center
18	JUL	1997	1989.7	Youth Center
18	JUL	1997	1989.8	Youth Center
18	JUL	1997	1990.2	Youth Center
25	JUL	1997	1997.6	Youth Center
25	JUL	1997	1997.7	Youth Center
25	JUL	1997	1999.2	Youth Center
25	JUL	1997	1999.3	Youth Center
25	JUL	1997	1999.5	Youth Center
12	AUG	1997	2052.7	Youth Center
12	AUG	1997	2052.8	Youth Center
12	AUG	1997	2053.2	Youth Center
4	OCT	1997	2123.6	Youth Center
4	OCT	1997	2124.1	Youth Center
4	OCT	1997	2124.2	Youth Center

YEAR: **1997**
LOCATION: **G - STREET**

DAY	MONTH	YEAR	FILE	LOCATION
18	MAY	1997	1948.7	G-Street
18	MAY	1997	1948.8	G-Street
1	JUN	1997	1941.1	G-Street
1	JUN	1997	1941.2	G-Street
1	JUN	1997	1941.4	G-Street
1	JUN	1997	1941.5	G-Street
1	JUN	1997	1941.7	G-Street
1	JUN	1997	1941.8	G-Street
1	JUN	1997	1942.1	G-Street
1	JUN	1997	1942.2	G-Street
1	JUN	1997	1942.4	G-Street
15	JUN	1997	1954.2	G-Street
15	JUN	1997	1954.4	G-Street
15	JUN	1997	1954.7	G-Street
20	JUL	1997	1993.2	G-Street
20	JUL	1997	1993.3	G-Street
20	JUL	1997	1993.5	G-Street
12	AUG	1997	2050.5	G-Street
12	AUG	1997	2050.6	G-Street
4	OCT	1997	2123.2	G-Street
4	OCT	1997	2123.3	G-Street
4	OCT	1997	2123.5	G-Street

YEAR: **1997**
LOCATION: **CANAL CREEK**

DAY	MONTH	YEAR	FILE	LOCATION
25	JUL	1997	2000.1	Canal Creek
25	JUL	1997	2000.8	Canal Creek
25	JUL	1997	2002.2	Canal Creek
25	JUL	1997	2002.4	Canal Creek
25	JUL	1997	2002.6	Canal Creek
25	JUL	1997	2002.8	Canal Creek

TABLE A.5 continued

YEAR: **1997**

LOCATION: **CHURCHVILLE**

DAY	MONTH	YEAR	FILE	LOCATION
1	JUN	1997	1939.1	Churchville
1	JUN	1997	1939.2	Churchville
1	JUN	1997	1939.5	Churchville
1	JUN	1997	1939.7	Churchville
1	JUN	1997	1939.8	Churchville
1	JUN	1997	1940.1	Churchville
1	JUN	1997	1940.2	Churchville
1	JUN	1997	1940.4	Churchville
1	JUN	1997	1940.5	Churchville
9	AUG	1997	2041.6	Churchville
9	AUG	1997	2041.8	Churchville
9	AUG	1997	2049.1	Churchville
9	AUG	1997	2049.2	Churchville
9	AUG	1997	2049.4	Churchville
9	AUG	1997	2049.5	Churchville
9	AUG	1997	2049.7	Churchville
9	AUG	1997	2050.2	Churchville
9	AUG	1997	2050.3	Churchville
24	AUG	1997	2061.2	Churchville
24	AUG	1997	2061.4	Churchville
24	AUG	1997	2061.5	Churchville
24	AUG	1997	2061.7	Churchville
24	AUG	1997	2063.2	Churchville
24	AUG	1997	2063.4	Churchville
24	AUG	1997	2063.5	Churchville
13	SEP	1997	2110.2	Churchville
13	SEP	1997	2110.6	Churchville
13	SEP	1997	2112.2	Churchville
13	SEP	1997	2112.4	Churchville
13	SEP	1997	2112.6	Churchville

TABLE A.5 continued

YEAR: **1996**
LOCATION: **JIM ZINC'S**

DAY	MONTH	YEAR	LOCATION
3	JUL	1996	Jim Zinc's
20	AUG	1996	Jim Zinc's
2	SEP	1996	Jim Zinc's
19	JUN	1996	Jim Zinc's
25	JUN	1996	Jim Zinc's
9	AUG	1996	Jim Zinc's

YEAR: **1996**
LOCATION: **LAUDERICK CREEK**

DAY	MONTH	YEAR	LOCATION
18	AUG	1996	Lauderick Creek
20	SEP	1996	Lauderick Creek

YEAR: **1996**
LOCATION: **G - STREET**

DAY	MONTH	YEAR	LOCATION
18	AUG	1996	G-Street
23	AUG	1996	G-Street
25	SEP	1996	G-Street

YEAR: **1996**
LOCATION: **G - STREET**

DAY	MONTH	YEAR	LOCATION	
20	AUG	1996	O-Field	
2	SEP	1996	O-Field	
21	SEP	1996	O-Field	
3	JUL	1996	O-Field	
20	AUG	1996	O-Field	
2	SEP	1996	O-Field	
21	SEP	1996	O-Field	
25	JUN	1996	O-Field	
9	AUG	1996	O-Field	

YEAR: **1996**
LOCATION: **DAVID SIMMON'S**

DAY	MONTH	YEAR	LOCATION
20	AUG	1996	David Simmon's
2	SEP	1996	David Simmon's
21	SEP	1996	David Simmon's
19	JUN	1996	David Simmon's
25	JUN	1996	David Simmon's
9	AUG	1996	David Simmon's

YEAR: **1996**
LOCATION: **CANAL CREEK**

DAY	MONTH	YEAR	LOCATION
14	AUG	1996	Canal Creek
18	AUG	1996	Canal Creek
20	SEP	1996	Canal Creek

YEAR: **1996**
LOCATION: **NATIONAL GUARD ARMORY**

DAY	MONTH	YEAR	LOCATION
18	AUG	1996	N. Guard Armory
25	SEP	1996	N. Guard Armory

YEAR: **1996**
LOCATION: **CHURCHVILLE**

DAY	MONTH	YEAR	LOCATION	
20	AUG	1996	Churchville	
22	AUG	1996	Churchville	
23	AUG	1996	Churchville	
25	AUG	1996	Churchville	
26	SEP	1996	Churchville	

TABLE A.5 continued

YEAR: **1996**
LOCATION: **BEACH POINT**

DAY	MONTH	YEAR	LOCATION
22	AUG	1996	Beach Point
23	AUG	1996	Beach Point
26	SEP	1996	Beach Point

YEAR: **1996**
LOCATION: **EAST BRANCH CANAL CREEK**

DAY	MONTH	YEAR	LOCATION
23	AUG	1996	E.B. Canal Creek
24	SEP	1996	E.B. Canal Creek

YEAR: **1996**
LOCATION: **YOUTH CENTER**

DAY	MONTH	YEAR	LOCATION
23	AUG	1996	Youth Center
20	SEP	1996	Youth Center

TABLE A.6

Dates and sample numbers of trace elements and heavy metals sorted by given year and location.

YEAR: **2000**
LOCATION: *

YEAR	MONTH	DAY	SAMPLE	LOCATION
2000	SEP	15	26	*
2000	SEP	15	27	*
2000	SEP	15	28	*
2000	SEP	15	29	*
2000	SEP	15	30	*
2000	SEP	15	31	*
2000	SEP	15	34	*
2000	SEP	15	35	*
2000	SEP	15	36	*
2000	SEP	15	37	*
2000	SEP	15	38	*
2000	SEP	15	40	*
2000	SEP	15	41	*
2000	SEP	15	42	*
2000	SEP	15	43	*
2000	SEP	15	44	*
2000	SEP	15	46	*
2000	SEP	15	47	*
2000	SEP	15	48	*
2000	SEP	15	49	*
2000	SEP	15	50	*

* Identifiers for all 2000 data are in possession of other company.
However, all concentration data has been provided for comparison with other years.

TABLE A.6 continued

YEAR: **1999**
LOCATION: **YOUTH CENTER**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	SEP	20	9972801	Youth Center
1999	SEP	20	9972801	Youth Center
1999	SEP	20	9972801	Youth Center
1999	SEP	20	9977601	Youth Center
1999	OCT	7	9932801	Youth Center
1999	OCT	7	9937601	Youth Center
1999	OCT	16	9912801	Youth Center
1999	OCT	16	9917601	Youth Center

YEAR: **1999**
LOCATION: **OTTER CREEK DRIVE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	SEP	27	9973901	Otter Creek Drive
1999	SEP	27	9977901	Otter Creek Drive
1999	OCT	6	9937901	Otter Creek Drive
1999	OCT	6	9937901	Otter Creek Drive
1999	OCT	9	9933901	Otter Creek Drive
1999	OCT	16	9913901	Otter Creek Drive
1999	OCT	16	9917901	Otter Creek Drive

YEAR: **1999**
LOCATION: **CONOWINGO ORCHARD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	OCT	18	9913701	Conowingo Orchard
1999	OCT	12	9933701	Conowingo Orchard
1999	OCT	18	9913801	Conowingo Orchard
1999	OCT	12	9933801	Conowingo Orchard
1999	OCT	12	9933801	Conowingo Orchard
1999	SEP	27	9973701	Conowingo Orchard
1999	SEP	27	9973801	Conowingo Orchard

YEAR: **1999**
LOCATION: **JONES FARM**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	SEP	20	9973201	Jones Farm
1999	OCT	8	9933201	Jones Farm
1999	OCT	8	9936901	Jones Farm
1999	OCT	16	9913201	Jones Farm
1999	OCT	16	9913201	Jones Farm
1999	OCT	16	9916901	Jones Farm
1999	OCT	16	9916901	Jones Farm

YEAR: **1999**
LOCATION: **LOHR'S ORCHARD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	SEP	20	9977401	Lohr's Orchard
1999	SEP	20	9977701	Lohr's Orchard
1999	OCT	6	9937401	Lohr's Orchard
1999	OCT	6	9937701	Lohr's Orchard
1999	OCT	18	9917401	Lohr's Orchard
1999	OCT	18	9917701	Lohr's Orchard

YEAR: **1999**
LOCATION: **TOWER HILL FARM**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	OCT	8	9934001	Tower Hill Farm
1999	OCT	8	9937101	Tower Hill Farm
1999	OCT	8	9974002	Tower Hill Farm
1999	OCT	8	9977101	Tower Hill Farm
1999	OCT	18	9914001	Tower Hill Farm
1999	OCT	18	9917101	Tower Hill Farm

YEAR: **1999**
LOCATION: **SHAWSVILLE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	OCT	12	9930201	Shawsville
1999	OCT	12	9933601	Shawsville
1999	OCT	18	9910201	Shawsville
1999	OCT	18	9913601	Shawsville
1999	SEP	23	9973601	Shawsville
1999	SEP	27	9970201	Shawsville

TABLE A.6 continued

YEAR: **1999**
LOCATION: **J - FIELD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	APR	8	9965001	J-Field
1999	APR	29	998A301	J-Field
1999	APR	29	998A301	J-Field
1999	APR	29	998B101	J-Field
1999	APR	29	998C301	J-Field
1999	APR	29	998D201	J-Field
1999	APR	29	998D301	J-Field
1999	APR	29	998E301	J-Field
1999	MAY	10	998A101	J-Field
1999	MAY	10	998A201	J-Field
1999	MAY	10	998B201	J-Field
1999	MAY	10	998B301	J-Field
1999	MAY	10	998D101	J-Field
1999	MAY	10	998E101	J-Field
1999	MAY	10	998E201	J-Field
1999	JUN	5	JFA1	J-Field
1999	JUN	5	JFA2	J-Field
1999	JUN	5	JFA3	J-Field
1999	JUN	5	JFC1	J-Field
1999	JUN	5	JFC2	J-Field
1999	JUN	5	JFC3	J-Field
1999	JUN	5	JFD1	J-Field
1999	JUN	5	JFD2	J-Field
1999	JUN	5	JFD3	J-Field
1999	JUN	5	JFE1	J-Field
1999	JUN	18	Condo 1	J-Field
1999	JUN	18	Condo 7	J-Field
1999	JUN	18	CONDO6	J-Field
1999	JUN	22	Condo 1	J-Field
1999	JUN	22	CONDO-2	J-Field
1999	JUN	22	CONDO-3	J-Field
1999	JUN	22	CONDO-4	J-Field
1999	JUN	22	CONDO5	J-Field
1999	JUN	22	CONDO6	J-Field
1999	JUN	22	CONDO7	J-Field
1999	JUL	6	Condo 2	J-Field
1999	JUL	6	Condo 7	J-Field
1999	JUL	6	CONDO6	J-Field
1999	JUL	30	9962603	J-Field
1999	JUL	30	9963003	J-Field
1999	JUL	30	9963403	J-Field
1999	JUL	30	9963503	J-Field
1999	JUL	30	9963503	J-Field

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	JUL	30	9964103	J-Field
1999	JUL	30	9965003	J-Field
1999	AUG	11	9965004	J-Field
1999	AUG	11	9965004	J-Field
1999	AUG	13	9972602	J-Field
1999	AUG	13	9973002	J-Field
1999	AUG	13	9973402	J-Field
1999	AUG	13	9973502	J-Field
1999	AUG	13	9974902	J-Field
1999	AUG	13	9975002	J-Field
1999	SEP	8	9962604	J-Field
1999	SEP	8	9963404	J-Field
1999	SEP	8	9963504	J-Field
1999	SEP	8	9964104	J-Field
1999	SEP	8	9964904	J-Field
1999	SEP	13	9973001	J-Field
1999	SEP	13	9973403	J-Field
1999	SEP	13	9974103	J-Field
1999	SEP	13	9974103	J-Field
1999	SEP	13	9974903	J-Field
1999	SEP	13	9975003	J-Field
1999	OCT	1	9933001	J-Field
1999	OCT	1	9934101	J-Field
1999	OCT	1	9934901	J-Field
1999	OCT	10	9933401	J-Field
1999	NOV	2	993A102	J-Field
1999	NOV	2	993A201	J-Field
1999	NOV	2	993A302	J-Field
1999	NOV	2	993B102	J-Field
1999	NOV	2	993B202	J-Field
1999	NOV	2	993B302	J-Field
1999	NOV	2	993C102	J-Field
1999	NOV	2	993C202	J-Field
1999	NOV	2	993C302	J-Field
1999	NOV	2	993D102	J-Field
1999	NOV	2	993D202	J-Field
1999	NOV	2	993D302	J-Field
1999	NOV	2	993D302	J-Field
1999	NOV	2	993E102	J-Field
1999	NOV	2	993E202	J-Field
1999	NOV	2	993E302	J-Field
1999	NOV	2	993E304	J-Field
1999	0	908	9963004	J-Field

TABLE A.6 continued

YEAR: **1999**
LOCATION: **RUMSEY ISLAND**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	OCT	11	993301	Rumsey Island
1999	OCT	11	9934801	Rumsey Island
1999	OCT	16	9914801	Rumsey Island
1999	OCT	16	9914801	Rumsey Island
1999	OCT	18	9913001	Rumsey Island
1999	OCT	6	9974801	Rumsey Island
1999	OCT	6	9973001	Rumsey Island
1999	OCT	6	9974801	Rumsey Island

YEAR: **1999**
LOCATION: **CYLBURN ARBORETUM**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	OCT	8	9974202	Cylburn Arboretum
1999	OCT	8	9974402	Cylburn Arboretum
1999	OCT	12	9934201	Cylburn Arboretum
1999	OCT	12	9934401	Cylburn Arboretum
1999	OCT	18	9914201	Cylburn Arboretum
1999	OCT	18	9914401	Cylburn Arboretum

YEAR: **1999**
LOCATION: **CLUSTER 13**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	JUL	29	9962902	Cluster 13
1999	JUL	29	9962902	Cluster 13
1999	SEP	20	9972901	Cluster 13
1999	SEP	20	9972901	Cluster 13
1999	SEP	20	9973501	Cluster 13
1999	OCT	8	9932901	Cluster 13
1999	OCT	8	9933501	Cluster 13
1999	OCT	16	9912901	Cluster 13
1999	OCT	16	9913501	Cluster 13
1999	OCT	16	9913591	Cluster 13

YEAR: **1999**
LOCATION: **SILVER LAKE DRIVE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	SEP	28	9974601	Silver Lake Drive
1999	SEP	28	9977501	Silver Lake Drive
1999	OCT	11	9934601	Silver Lake Drive
1999	OCT	11	9937501	Silver Lake Drive
1999	OCT	16	9914601	Silver Lake Drive
1999	OCT	16	9917501	Silver Lake Drive

YEAR: **1999**
LOCATION: **CHURCHVILLE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	JUL	24	9963602	Churchville
1999	JUL	29	9964002	Churchville
1999	JUL	29	9964302	Churchville
1999	AUG	2	9932901	Churchville
1999	AUG	5	9932901	Churchville
1999	AUG	5	9934001	Churchville
1999	AUG	5	9932801	Churchville
1999	AUG	10	9974401	Churchville
1999	SEP	25	993801	Churchville
1999	SEP	25	9973801	Churchville
1999	SEP	25	9974401	Churchville
1999	OCT	12	9934401	Churchville
1999	NOV	8	9932902	Churchville
1999	NOV	8	9933802	Churchville
1999	NOV	8	99334402	Churchville
1999	NOV	8	9932902	Churchville

TABLE A.6 continued

YEAR: **1999**
LOCATION: **CLUSTER 3**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1999	AUG	11	9964601	Cluster 3
1999	AUG	23	9962702	Cluster 3
1999	AUG	23	9963102	Cluster 3
1999	AUG	23	9964202	Cluster 3
1999	AUG	23	9964602	Cluster 3
1999	AUG	23	9964602	Cluster 3
1999	AUG	23	9964702	Cluster 3
1999	SEP	20	9972701	Cluster 3
1999	SEP	20	9972701	Cluster 3
1999	SEP	20	9973101	Cluster 3
1999	SEP	20	9974201	Cluster 3
1999	SEP	20	9974601	Cluster 3
1999	SEP	20	9974701	Cluster 3
1999	SEP	20	9974801	Cluster 3
1999	OCT	6	9932701	Cluster 3
1999	OCT	6	9933101	Cluster 3
1999	OCT	6	9933101	Cluster 3
1999	OCT	6	9933701	Cluster 3
1999	OCT	6	9933701	Cluster 3
1999	OCT	6	9934201	Cluster 3
1999	OCT	6	9934201	Cluster 3
1999	OCT	6	9934601	Cluster 3
1999	OCT	6	9934701	Cluster 3
1999	OCT	6	9934801	Cluster 3

TABLE A.6 continued

YEAR: **1998**
LOCATION: **D - FIELD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	14	992054	D-Field
1999	JUL	14	992055	D-Field
1998	JUL	14	992056	D-Field
1998	JUL	14	992057	D-Field
1998	JUL	14	992058	D-Field
1998	JUL	14	992060	D-Field
1998	JUL	14	992061	D-Field
1998	JUL	14	992156	D-Field
1998	JUL	14	992156	D-Field
1998	JUL	14	992157	D-Field
1998	JUL	14	992157	D-Field
1998	JUL	21	992059	D-Field
1998	AUG	4	992062	D-Field
1998	AUG	20	992063	D-Field

YEAR: **1998**
LOCATION: **ABERDEEN POST**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	AUG	26	992153	Aberdeen Post
1998	AUG	26	992153	Aberdeen Post
1998	OCT	7	992154	Aberdeen Post
1998	OCT	7	992154	Aberdeen Post
1998	OCT	7	992155	Aberdeen Post
1998	OCT	7	992155	Aberdeen Post
1998	OCT	13	992158	Aberdeen Post
1998	OCT	13	992158	Aberdeen Post

YEAR: **1998**
LOCATION: **CYLBURN ARBORETUM**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	18	992135	Cylburn Arboretum
1998	JUL	18	992136	Cylburn Arboretum

YEAR: **1998**
LOCATION: **O - FIELD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	MAY	19	992041	O-Field
1998	MAY	19	992041	O-Field
1998	MAY	19	992044	O-Field
1998	JUN	27	992029	O-Field
1998	JUN	27	992030	O-Field
1998	JUN	27	992031	O-Field
1998	JUN	27	992032	O-Field
1998	JUN	27	992033	O-Field
1998	JUN	27	992034	O-Field
1998	JUN	27	992036	O-Field
1998	JUN	27	992037	O-Field
1998	JUN	27	992039	O-Field
1998	JUN	27	992040	O-Field
1998	JUN	27	992042	O-Field
1998	JUN	27	992042	O-Field
1998	JUN	27	992046	O-Field
1998	JUN	27	995042	O-Field
1998	JUL	6	992038	O-Field
1998	JUL	6	992044	O-Field
1998	JUL	6	992045	O-Field
1998	JUL	6	992047	O-Field
1998	JUL	6	992048	O-Field
1998	JUL	6	992049	O-Field
1998	JUL	6	992050	O-Field
1998	JUL	6	992051	O-Field
1998	JUL	6	992167	O-Field
1998	JUL	18	992168	O-Field
1998	JUL	21	992035	O-Field
1998	JUL	21	992035	O-Field
1998	JUL	21	992039	O-Field
1998	JUL	21	992039	O-Field
1998	JUL	21	992043	O-Field
1998	JUL	21	992046	O-Field
1998	JUL	21	992052	O-Field
1998	JUL	27	992035	O-Field
1998	AUG	3	992036	O-Field
1998	AUG	25	992048	O-Field
1998	AUG	31	992053	O-Field
1998	SEP	16	992040	O-Field

TABLE A.6 continued

YEAR: **1998**

LOCATION: **J - FIELD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	MAY	26	992064	J-Field
1998	MAY	26	992070	J-Field
1998	MAY	26	992077	J-Field
1998	MAY	26	992082	J-Field
1998	MAY	26	992082	J-Field
1998	MAY	26	992088	J-Field
1998	MAY	26	992092	J-Field
1998	MAY	26	992098	J-Field
1998	MAY	26	992098	J-Field
1998	JUL	6	992065	J-Field
1998	JUL	6	992071	J-Field
1998	JUL	6	992071	J-Field
1998	JUL	6	992083	J-Field
1998	JUL	6	992093	J-Field
1998	JUL	6	992093	J-Field
1998	JUL	6	992096	J-Field
1998	JUL	14	992084	J-Field
1998	JUL	21	992052	J-Field
1998	JUL	25	992026	J-Field
1998	JUL	25	992066	J-Field
1998	JUL	25	992072	J-Field
1998	JUL	25	992075	J-Field
1998	JUL	25	992075	J-Field
1998	JUL	25	992078	J-Field
1998	JUL	25	992085	J-Field
1998	JUL	25	992089	J-Field
1998	JUL	25	992094	J-Field
1998	JUL	25	992097	J-Field
1998	JUL	25	992099	J-Field
1998	AUG	25	992067	J-Field
1998	AUG	25	992079	J-Field
1998	AUG	25	992090	J-Field
1998	AUG	25	992100	J-Field
1998	SEP	17	992080	J-Field
1998	SEP	17	992091	J-Field
1998	SEP	17	992095	J-Field
1998	SEP	25	992073	J-Field
1998	SEP	25	992086	J-Field
1998	OCT	2	992068	J-Field
1998	OCT	2	992074	J-Field
1998	OCT	2	992076	J-Field
1998	OCT	2	992081	J-Field
1998	OCT	2	992087	J-Field
1998	OCT	2	992101	J-Field
1998	OCT	3	992069	J-Field

YEAR: **1998**

LOCATION: **CHURCHVILLE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	28	992027	Churchville
1998	OCT	2	992028	Churchville
1998	JUL	28	992102	Churchville
1998	JUL	28	992103	Churchville
1998	JUL	28	992104	Churchville
1998	JUL	28	992105	Churchville
1998	JUL	28	992106	Churchville
1998	JUL	28	992107	Churchville
1998	JUL	28	992103	Churchville

YEAR: **1998**

LOCATION: **CARROLL ISLAND**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	4	992136	Carroll Island
1998	AUG	4	992138	Carroll Island
1998	OCT	8	992139	Carroll Island

YEAR: **1998**

LOCATION: **CONOWINGO ORCHARD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	17	992123	Conowingo Orchard
1998	JUL	17	992124	Conowingo Orchard
1998	SEP	23	992125	Conowingo Orchard

YEAR: **1998**

LOCATION: **CLUSTER 13**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	AUG	4	992149	Cluster 13
1998	OCT	7	992150	Cluster 13
1998	AUG	4	992151	Cluster 13
1998	OCT	7	992152	Cluster 13

TABLE A.6 continued

YEAR: **1998**
LOCATION: **GRACE'S QUARTERS**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	AUG	4	992140	Grace's Quarters
1998	AUG	4	992141	Grace's Quarters

YEAR: **1998**
LOCATION: **JONES FARM**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	APR	25	992111	Jones Farm
1998	JUL	29	992112	Jones Farm
1998	JUL	29	992113	Jones Farm

YEAR: **1998**
LOCATION: **LOHR'S ORCHARD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	17	992121	Lohr's Orchard
1998	OCT	1	992122	Lohr's Orchard

YEAR: **1998**
LOCATION: **RUMSEY MANSION**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	30	992117	Rumsey Mansion
1998	SEP	23	992118	Rumsey Mansion
1998	JUL	24	992119	Rumsey Mansion
1998	SEP	25	992120	Rumsey Mansion

YEAR: **1998**
LOCATION: **WESTWOOD ROAD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	29	992142	Westwood Road
1998	SEP	24	992143	Westwood Road
1998	JUL	29	992144	Westwood Road
1998	SEP	23	992145	Westwood Road
1998	OCT	8	992146	Westwood Road
1998	OCT	30	992147	Westwood Road
1998	NOV	1	992148	Westwood Road

YEAR: **1998**
LOCATION: **SILVER LAKE DRIVE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	30	992133	Silver Lake Drive
1998	JUL	30	992134	Silver Lake Drive

YEAR: **1998**
LOCATION: **SHAWSVILLE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	18	992129	Shawsville
1998	SEP	23	992130	Shawsville
1998	JUL	18	992131	Shawsville
1998	SEP	23	992132	Shawsville

YEAR: **1998**
LOCATION: **OTTER CREEK DRIVE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JAN	17	992114	Otter Creek Drive
1998	JUL	17	992115	Otter Creek Drive
1998	OCT	1	992116	Otter Creek Drive

YEAR: **1998**
LOCATION: **TOWER HILL DRIVE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	30	992126	Tower Hill Farm
1998	SEP	23	992127	Tower Hill Farm
1998	JUL	30	992128	Tower Hill Farm
1998	JUL	18	992129	Tower Hill Farm
1998	JUL	18	992131	Tower Hill Farm

YEAR: **1998**
LOCATION: **YOUTH CENTER**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1998	JUL	29	992109	Youth Center
1998	SEP	25	992110	Youth Center
1997	SEP	17	970346	Youth Center

TABLE A.6 continued

YEAR: **1997**
LOCATION: **BUSH RIVER**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	JUN	26	970016	Bush River
1997	JUN	26	970017	Bush River
1997	JUN	26	970018	Bush River
1997	JUN	26	970019	Bush River
1997	JUN	26	970020	Bush River
1997	JUN	26	970022	Bush River
1997	JUN	26	970023	Bush River
1997	JUN	26	970024	Bush River
1997	JUN	26	970026	Bush River
1997	JUN	26	970033	Bush River
1997	JUN	26	970034	Bush River
1997	JUN	26	970035	Bush River
1997	JUN	26	970010	Bush River
1997	JUN	26	970011	Bush River
1997	JUN	26	970012	Bush River
1997	JUN	26	970014	Bush River
1997	AUG	11	970072	Bush River
1997	AUG	11	970073	Bush River
1997	AUG	11	970074	Bush River
1997	AUG	11	970077	Bush River
1997	AUG	11	970078	Bush River
1997	AUG	11	970079	Bush River
1997	AUG	11	970080	Bush River
1997	AUG	11	970081	Bush River
1997	AUG	11	970082	Bush River
1997	AUG	11	970083	Bush River
1997	AUG	11	970084	Bush River
1997	AUG	11	970085	Bush River
1997	AUG	11	970086	Bush River
1997	AUG	11	970087	Bush River
1997	AUG	11	970119	Bush River
1997	AUG	11	970120	Bush River
1997	AUG	11	970122	Bush River
1997	AUG	11	970125	Bush River
1997	AUG	11	970126	Bush River
1997	AUG	11	970127	Bush River
1997	AUG	11	970128	Bush River
1997	AUG	11	970130	Bush River
1997	AUG	11	970131	Bush River
1997	AUG	11	970136	Bush River
1997	AUG	11	970137	Bush River
1997	AUG	11	970139	Bush River
1997	AUG	11	970140	Bush River
1997	AUG	25	970025	Bush River
1997	AUG	25	970029	Bush River
1997	AUG	25	970005	Bush River
1997	AUG	25	970008	Bush River
1997	AUG	25	970013	Bush River
1997	AUG	25	970015	Bush River
1997	AUG	26	970021	Bush River
1997	AUG	26	970027	Bush River
1997	AUG	26	970028	Bush River
1997	AUG	26	970030	Bush River
1997	AUG	26	970031	Bush River
1997	AUG	26	970032	Bush River
1997	AUG	26	970036	Bush River
1997	AUG	26	970037	Bush River
1997	AUG	26	970038	Bush River
1997	AUG	26	970006	Bush River
1997	AUG	26	970007	Bush River
1997	AUG	26	970009	Bush River
1997	SEP	17	970316	Bush River
1997	SEP	17	970320	Bush River
1997	SEP	17	970321	Bush River
1997	SEP	17	970322	Bush River
1997	SEP	17	970323	Bush River
1997	SEP	17	970326	Bush River
1997	SEP	17	970329	Bush River
1997	SEP	17	970332	Bush River
1997	SEP	17	970333	Bush River
1997	SEP	17	970336	Bush River
1997	SEP	17	970338	Bush River
1997	SEP	17	970342	Bush River
1997	SEP	17	970343	Bush River
1997	SEP	17	970347	Bush River

TABLE A.6 continued

YEAR: **1997**
LOCATION: **WEST BRANCH CANAL CREEK**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	AUG	19	970039	W.B. Canal Creek
1997	AUG	19	970040	W.B. Canal Creek
1997	AUG	19	970041	W.B. Canal Creek
1997	AUG	19	970044	W.B. Canal Creek
1997	AUG	19	970046	W.B. Canal Creek
1997	AUG	19	970047	W.B. Canal Creek
1997	AUG	19	970042	W.B. Canal Creek
1997	AUG	19	970043	W.B. Canal Creek
1997	AUG	19	970048	W.B. Canal Creek
1997	AUG	19	970049	W.B. Canal Creek
1997	AUG	19	970045	W.B. Canal Creek

YEAR: **1997**
LOCATION: **BEACH POINT**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	SEP	17	970337	Beach Point

YEAR: **1997**
LOCATION: **EAST BRANCH CANAL CREEK**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	SEP	17	970340	E.B. Canal Creek

YEAR: **1997**
LOCATION: **NATIONAL GUARD ARMORY**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	SEP	17	970344	N. Guard Armory

YEAR: **1997**
LOCATION: **G - STREET**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	SEP	17	970345	G-Street

YEAR: **1997**
LOCATION: **CHURCHVILLE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	SEP	17	970335	Churchville
1997	SEP	17	970339	Churchville
1997	SEP	17	970334	Churchville
1997	SEP	17	970331	Churchville
1997	SEP	17	970349	Churchville
1997	SEP	17	970317	Churchville
1997	AUG	9	970096	Churchville
1997	AUG	9	970098	Churchville
1997	AUG	9	970099	Churchville

YEAR: **1997**
LOCATION: **CANAL CREEK**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	JUL	21	970052	Canal Creek
1997	JUL	21	970101	Canal Creek
1997	JUL	21	970053	Canal Creek
1997	JUL	21	970133	Canal Creek
1997	JUL	21	970134	Canal Creek
1997	JUL	21	970135	Canal Creek
1997	JUL	21	970056	Canal Creek
1997	JUL	30	970075	Canal Creek
1997	JUL	30	970107	Canal Creek
1997	JUL	30	970071	Canal Creek
1997	AUG	4	970103	Canal Creek
1997	AUG	13	970063	Canal Creek
1997	AUG	13	970064	Canal Creek
1997	AUG	13	970065	Canal Creek
1997	AUG	13	970060	Canal Creek
1997	AUG	13	970090	Canal Creek
1997	AUG	24	970113	Canal Creek
1997	AUG	24	970115	Canal Creek
1997	AUG	24	970138	Canal Creek
1997	AUG	24	970069	Canal Creek
1997	AUG	24	970070	Canal Creek
1997	AUG	24	970102	Canal Creek

TABLE A.6 continued

YEAR: **1997**
LOCATION: **O - FIELD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1997	JUL	21	970055	O-Field
1997	JUL	21	970057	O-Field
1997	JUL	21	970058	O-Field
1997	JUL	21	970091	O-Field
1997	JUL	21	970092	O-Field
1997	JUL	29	970068	O-Field
1997	JUL	29	970104	O-Field
1997	JUL	29	970105	O-Field
1997	JUL	29	970108	O-Field
1997	JUL	29	970110	O-Field
1997	JUL	29	970111	O-Field
1997	JUL	29	970114	O-Field
1997	JUL	30	970109	O-Field
1997	AUG	4	970123	O-Field
1997	AUG	4	970124	O-Field
1997	AUG	4	970129	O-Field
1997	AUG	9	970106	O-Field
1997	AUG	12	970051	O-Field
1997	AUG	12	970061	O-Field
1997	AUG	12	970062	O-Field
1997	AUG	12	970088	O-Field
1997	AUG	12	970089	O-Field
1997	AUG	12	970094	O-Field
1997	AUG	12	970095	O-Field
1997	AUG	12	970097	O-Field
1997	AUG	15	970076	O-Field
1997	AUG	15	970100	O-Field
1997	AUG	15	970112	O-Field
1997	AUG	15	970116	O-Field
1997	AUG	15	970118	O-Field
1997	AUG	15	970121	O-Field
1997	AUG	15	970132	O-Field
1997	AUG	19	970117	O-Field
1997	AUG	22	970050	O-Field
1997	AUG	22	970054	O-Field
1997	AUG	22	970059	O-Field
1997	AUG	22	970066	O-Field
1997	AUG	22	970067	O-Field
1997	AUG	22	970093	O-Field
1997	SEP	17	970315	O-Field
1997	SEP	17	970318	O-Field
1997	SEP	17	970319	O-Field
1997	SEP	17	970324	O-Field
1997	SEP	17	970325	O-Field
1997	SEP	17	970327	O-Field
1997	SEP	17	970328	O-Field
1997	SEP	17	970330	O-Field
1997	SEP	17	970341	O-Field
1997	SEP	17	970348	O-Field

TABLE A.6 continued

YEAR: **1996**
LOCATION: **CHURCHVILLE**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	AUG	26	96-0872	Churchville
1996	AUG	26	96-0873	Churchville
1996	AUG	26	96-0874	Churchville
1996	AUG	26	96-0875	Churchville
1996	AUG	26	96-0876	Churchville
1996	AUG	26	96-0877	Churchville
1996	AUG	26	96-0878	Churchville
1996	AUG	26	96-0879	Churchville
1996	SEP	29	96-1270	Churchville
1996	SEP	29	96-1274	Churchville
1996	SEP	29	96-1275	Churchville
1996	SEP	29	96-1276	Churchville
1996	SEP	29	96-1271	Churchville
1996	SEP	29	96-1272	Churchville
1996	SEP	29	96-1273	Churchville
1996	SEP	29	96-1097	Churchville
1996	SEP	29	96-1096	Churchville
1996	SEP	29	96-1278	Churchville
1996	SEP	29	96-1277	Churchville

YEAR: **1996**
LOCATION: **CANAL CREEK**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	AUG	26	96-0880	Canal Creek
1996	AUG	26	96-0881	Canal Creek
1996	AUG	26	96-0882	Canal Creek
1996	AUG	26	96-0883	Canal Creek
1996	AUG	26	96-0884	Canal Creek
1996	AUG	26	96-0885	Canal Creek
1996	AUG	26	96-0886	Canal Creek
1996	AUG	26	96-0887	Canal Creek
1996	AUG	26	96-0870	Canal Creek
1996	AUG	26	96-0871	Canal Creek
1996	AUG	26	96-0888	Canal Creek
1996	AUG	26	96-0889	Canal Creek
1996	SEP	29	96-1257	Canal Creek
1996	SEP	29	96-1258	Canal Creek
1996	SEP	29	96-1260	Canal Creek
1996	SEP	29	96-1261	Canal Creek
1996	SEP	29	96-1262	Canal Creek
1996	SEP	29	96-1259	Canal Creek
1996	SEP	29	96-1092	Canal Creek
1996	SEP	29	96-1093	Canal Creek
1996	SEP	29	96-1280	Canal Creek
1996	SEP	29	96-1279	Canal Creek
1996	SEP	29	96-1282	Canal Creek
1996	SEP	29	96-1281	Canal Creek

YEAR: **1996**
LOCATION: **O - FIELD**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	SEP	29	96-1267	O-Field
1996	SEP	29	96-1269	O-Field
1996	SEP	29	96-1263	O-Field
1996	SEP	29	96-1264	O-Field
1996	SEP	29	96-1265	O-Field
1996	SEP	29	96-1268	O-Field
1996	SEP	29	96-1266	O-Field
1996	SEP	29	96-1095	O-Field
1996	SEP	29	96-1094	O-Field

YEAR: **1996**
LOCATION: **EAST BRANCH CANAL CREEK**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	SEP	29	96-1283	E.B. Canal Creek

YEAR: **1996**
LOCATION: **YOUTH CENTER**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	SEP	29	96-1284	Youth Center

TABLE A.6 continued

YEAR: **1996**
LOCATION: **BEACH POINT**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	SEP	29	96-1285	Beach Point

YEAR: **1996**
LOCATION: **LAUDERICK CREEK**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	SEP	29	96-1286	Lauderick Creek

YEAR: **1996**
LOCATION:**G - STREET**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	SEP	29	96-1287	G-Street

YEAR: **1996**
LOCATION: **NATIONAL GUARD ARMORY**

YEAR	MONTH	DAY	SAMPLE	LOCATION
1996	SEP	29	96-1288	N. Guard Armory

TABLE A.7

Dates and sample identification numbers for radionuclides sorted by given year and location.

LOCATION: **CARROLL ISLAND**

YEAR	SAMPLE	LOCATION
98-99	CILB9801	Carroll Island

LOCATION: **CLUSTER 13**

YEAR	SAMPLE	LOCATION
98-99	CL13LB9902	Cluster13
98-99	CL13LB9901	Cluster13
98-99	CL3DB9901	Cluster13
98-99	CL3LB9901	Cluster13
98-99	CL3PL9901	Cluster13

LOCATION: **GRACE'S QUARTERS**

YEAR	SAMPLE	LOCATION
98-99	GOLB9801	Grace's Quarters

LOCATION: **ABERDEEN POST**

YEAR	SAMPLE	LOCATION
98-99	UPLB9801	Aberdeen Post

LOCATION: **WESTWOOD ROAD**

YEAR	SAMPLE	LOCATION
98-99	WWLB9801	Westwood Road
98-99	WWLB9802	Westwood Road

LOCATION: **CYLBURN ARBORETUM**

YEAR	SAMPLE	LOCATION
98-99	ABLB9901	Cylburn Arboretum
98-99	ABLB9902	Cylburn Arboretum
98-99	ABPL9901	Cylburn Arboretum

TABLE A.7 continued

LOCATION: **CANAL CREEK**

YEAR	SAMPLE	LOCATION
98-99	CCLB9901	Canal Creek
98-99	CCLB9902	Canal Creek
98-99	CCPL9901	Canal Creek

LOCATION: **CHURCHVILLE**

YEAR	SAMPLE	LOCATION
98-99	CVDB9901	Churchville
98-99	CVLB9901	Churchville
98-99	CVPL9901	Churchville

LOCATION: **J - FIELD**

YEAR	SAMPLE	LOCATION
98-99	JFDDB9902	J-Field
98-99	JFLDDB9901	J-Field
98-99	JFLDLB9901	J-Field
98-99	JFDPL9901	J-Field
98-99	JFDPL9902	J-Field
98-99	JFLB9901	J-Field
98-99	JFLB9902	J-Field
98-99	JFPL9901	J-Field

LOCATION: **LOHR'S ORCHARD**

YEAR	SAMPLE	LOCATION
98-99	LOLB9901	Lohr's Orchard
98-99	LOLB9902	Lohr's Orchard
98-99	LOPL9901	Lohr's Orchard

LOCATION: **OTTER CREEK DRIVE**

YEAR	SAMPLE	LOCATION
98-99	OPLB9901	Otter Creek Drive
98-99	OPLB9902	Otter Creek Drive
98-99	OPPL9901	Otter Creek Drive

TABLE A.7 continued

LOCATION: **RUMSEY MANSION**

YEAR	SAMPLE	LOCATION
98-99	RMLB9901	Rumsey Mansion
98-99	RMLB9902	Rumsey Mansion
98-99	RMPL9901	Rumsey Mansion

LOCATION: **SILVER LAKE DRIVE**

YEAR	SAMPLE	LOCATION
98-99	SLLB9901	Silver Lake Drive
98-99	SLLB9902	Silver Lake Drive
98-99	SLPL9901	Silver Lake Drive

LOCATION: **SHAWSVILLE**

YEAR	SAMPLE	LOCATION
98-99	SVLB9901	Shawsville
98-99	SVLB9902	Shawsville
98-99	SVPL9901	Shawsville

LOCATION: **TOWER HILL FARM**

YEAR	SAMPLE	LOCATION
98-99	THLB9901	Tower Hill Farm
98-99	THLB9902	Tower Hill Farm
98-99	THPL9901	Tower Hill Farm

LOCATION: **YOUTH CENTER**

YEAR	SAMPLE	LOCATION
98-99	YCLB9901	Youth Center
98-99	YCLB9902	Youth Center
98-99	YCPL9901	Youth Center

TABLE A.8

Dates and samples identification numbers of pesticides sorted by given year and location.

LOCATION: **YOUTH CENTER**

YEAR	SAMPLE	LOCATION
98-99	YCLB9903	Youth Center

LOCATION: **OTTER CREEK DRIVE**

YEAR	SAMPLE	LOCATION
98-99	OPLB9903	Otter Creek Drive

LOCATION: **LOHR'S ORCHARD**

YEAR	SAMPLE	LOCATION
98-99	LOLB9903	Lohr's Orchard

LOCATION: **TOWER HILL FARM**

YEAR	SAMPLE	LOCATION
98-99	THLB9903	Tower Hill Farm

LOCATION: **SILVER LAKE DRIVE**

YEAR	SAMPLE	LOCATION
98-99	SLLB9903	Silver Lake Drive

LOCATION: **RUMSEY MANSION**

YEAR	SAMPLE	LOCATION
98-99	RMLB9903	Rumsey Mansion

TABLE A.8 continued

LOCATION: **SHAWSVILLE**

YEAR	SAMPLE	LOCATION
98-99	SVLB9903	Shawsville

LOCATION: **CANAL CREEK**

YEAR	SAMPLE	LOCATION
98-99	CCLB9903	Canal Creek

LOCATION: **CHURCHVILLE**

YEAR	SAMPLE	LOCATION
98-99	CVPL9801	Churchville
98-99	CVDB9801	Churchville

LOCATION: **CLUSTER 3**

YEAR	SAMPLE	LOCATION
98-99	CL3LB9902	Cluster3
98-99	CL3PL9902	Cluster3

LOCATION: **J - FIELD**

YEAR	SAMPLE	LOCATION
98-99	JFLDDB9903	J-Field
98-99	JFLB9903	J-Field
98-99	JFLDPL9903	J-Field
98-99	JFLDLB9902	J-Field
98-99	JFLDLB9903	J-Field

LOCATION: CYLBURN ARBORETUM

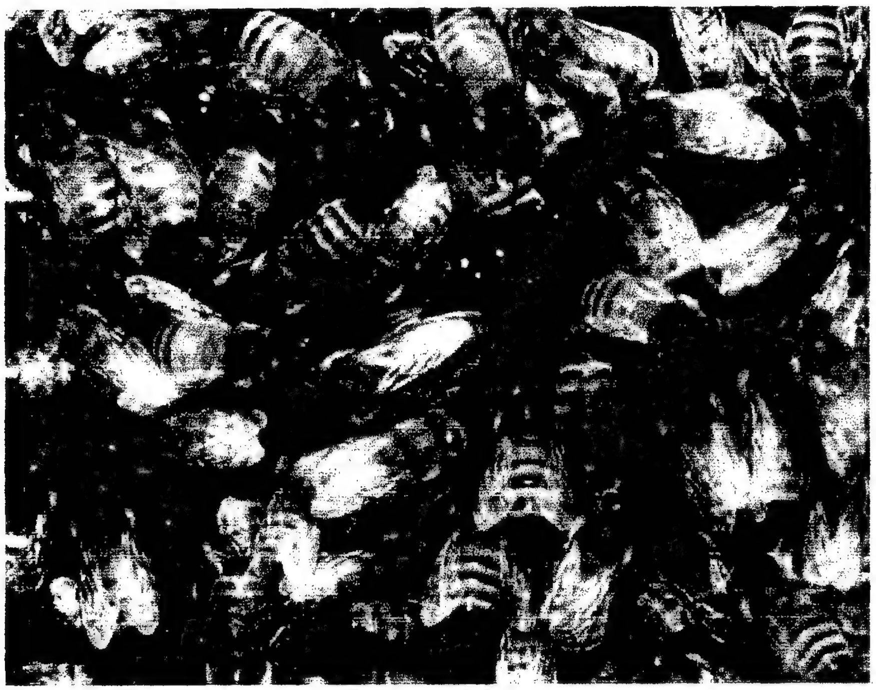
YEAR	SAMPLE	LOCATION
98-99	ABLB9903	Cylburn Arboretum

Appendix B:

The Effects of Methyl Parathion on the Colony Dynamics of *Apis mellifera*

Although this thesis could be simply referenced and information extracted that is specifically relevant to the objective of our APG studies, a copy of this thesis is included here in response to concerns of APG Installation Restoration Project Officers about the difficulty of obtaining thesis documents, particularly one published in another country.

The Effects of Methyl Parathion on the Colony Dynamics of *Apis mellifera*



A thesis submitted in partial fulfilment
of the requirements for the degree of

Master of Science in Ecology

At Massey University,
Palmerston North,
New Zealand

Michelle Anne Taylor
2000

TABLE OF CONTENTS

ABSTRACT

The detrimental effects of pesticides to honey bee colonies were assessed using a combination of electronic and manual sampling techniques. Initial experiments determined that electronic bee counters could be used to identify and monitor toxic events occurring in honey bee colonies, and also identified that 30 minutes after application, the bees did not avoid direct contact with methyl parathion. Dead bee counts, flight activity, percent return of foragers, and determination of colony composition were used to assess the effects of methyl parathion on the colony dynamics of *Apis mellifera*. In particular, the combination of dead bee counts, colony composition analysis, and "real time" data, provided an extensive monitoring system that enabled the progression of colony recovery to be followed, and generated information of use for the application of pesticides in the local environment.

The analysis of colony composition identified that brood declined in response to decreased worker bees, and that colony recovery was dependent on brood and food reserves within the hive.

The foraging activity of honey bee colonies dosed with methyl parathion was lower than that of untreated colonies because their flight activity and percent return rate declined for at least six weeks following methyl parathion application.

Keywords: Honey bees, *Apis mellifera*, Pesticide effects, Methyl parathion, Flight-monitoring

Explanation of Text

These studies were conducted through a Study Abroad Program between Massey University and the University of Montana (UM). This research was conducted under the auspices of Jerry Bromenshenk at the University of Montana, who leads the team that designed the bee counters that I used to study the progress of methyl parathion treated colonies, and follow the colony composition through weekly checks.

Outline of Honeybee research at Montana University

UM assesses areas of environmental interest by analysing the chemicals that honey bees accumulate in their hives. Through identification of these chemicals we have shown that pesticides also accumulate within the hive. UM aims to identify behavioural activity that will flag chemical changes within the environment so that chemical analysis is only conducted when necessary. In an attempt to identify and calibrate this detection system UM has designed an electronic bee counter which records the number of honey bees entering and leaving the hive.

American date notation has been used in sections of chapter 2 and chapter 3 of this thesis to prevent confusion whilst completing these experiments in America. ie. mm/dd/yy.

ACKNOWLEDGEMENTS

I appreciate the time and effort Dr Jerry Bromenshenk, my adviser at Montana University, United States of America, has given to enable the completion of this thesis. Also for the financial assistance provided through his funding, the invaluable advice and experiences he shared, and for believing in me.

I would like to thank my primary supervisor, Professor Brian Springett, for help in editing this manuscript, and for providing guidance and constructive comments throughout this study.

I am especially thankful to my husband and best friend, Byron Taylor for his never ending support, encouragement and selflessness. For taking a year off from teaching to work with me on the bee project and for enduring the inevitable stings.

Thank you to the technical staff of Montana University, past and present, who have provided insight and support as well as making this an enjoyable experience. I would especially like to thank Dr Bruce King and Robert Seccomb for their amazing abilities to design systems and make computers comply. Dr Garon Smith and Dave Jones for their support and chemistry related and advice. Lenny Hahn and the work studies for their reliable bee collecting and counting. Thanks to Dr Colin Henderson for his invaluable guidance and patience in data analysis.

I would like to acknowledge the use of honey bee colonies from the Beltsville Bee Laboratory, Maryland USA. Huge thanks to Dr Jeff Pettis who provided ongoing encouragement and discussion of experimental design and analysis, Dr H. Shimanuki for supplying numerous references, and Mark Feldlaufer for providing the initial contacts.

My parents, Graeme and Jeanette Ward, have been wonderful throughout my studies with encouraging words and letters, as have my new parents, Peter and Margaret Taylor, over this last year, and my four sets of grandparents that have taken great interest in my "study with the bees".

Thanks to a wonderful beekeeper and friend Dave Simmons for the use of his property, his support, advice and friendly hassles over coffee. The Susquehanna Beekeepers Association for providing valuable insights into the beekeeping strategies in Maryland, USA, as well as taking time leave from work to help with the research.

I thank the Massey University Study Abroad Program for enabling the dream to study overseas become a reality. Especially Dr Russell Death for inspiring me to apply. The administration staff of the ecology department at Massey University, Erica Reid and Jodi Matenga have been great for keeping the communication lines open whilst I was in America.

I am grateful for the editing my uncle, David Beach, provided and for the way he has gone out of his way to make this thesis happen. Truly amazing.

Great thanks to all the people we had contact with at the Aberdeen Proving Ground post in Edgewood including John Wrobel, Pete Pritchard, Pop Schenk, Pop Taylor, Bruce, Big John, Larry Overbay and Walter Vuncanon.

Most importantly I would like to thank God for the joy, peace, sound advice, and assurance, that He has filled my life with throughout the completion of this thesis.

I would like to dedicate this thesis to my husband and friend,
Byron Taylor.

Chapter 1: General Introduction

Apis mellifera, honey bees, are social insects which play an important role in pollinating much of the world's food supply, simply by foraging. One in every three mouthfuls we swallow is prepared from insect pollinated plants (McGregor 1976, Barker *et al.* 1979). So to protect our crops from the 4% of insects that are pests of economic importance (Heading 1983), pesticide sprays have become an integral part of general crop management (Lyman 1979). Protection of beneficial insects, especially honey bees, from pesticides during pollination and crop growth is critical world-wide (Johansen 1979, Mel'nichenko 1980, Metcalfe 1980, Rhodes *et al.* 1980, Ware 1980, Crane 1981, Field 1981, Melksham *et al.* 1981, Mayer *et al.* 1983, Erickson 1994). Despite this importance, the effects of pesticides on colony dynamics and how this affects pollination remains one of the weakest links in our understanding of agro-ecosystem functioning and the assurance of crop yields.

Honey bees have large workforces in comparison to other *Apis* species and this enables them to forage, and therefore pollinate, more effectively (Jamieson 1950). New Zealand estimates the value of honey bee pollination at over 60 times the value of the products and services they produce (Matheson 1997). A survey by MacFarlane and Ferguson (1984) deemed honey bees as New Zealand's most important kiwifruit pollinators as they were present in 95% of the fifty-four orchards surveyed, and were four times more numerous than the next most common insect group, the bumble bees. Pollination is also critical to the United States of America, where their annual value of crops pollinated by honey bees is around 24 billion dollars, and commercial bee pollination produces an annual profit of around 10 billion dollars (http://www.cyberbee.net/research.htm).

Beekeepers, pollination companies, and scientists alike, are interested in the impact that pesticides have on the entire colony. To understand the immediate and long–term effects that pesticides cause it is important to study the bees' behavioural responses to pesticides in both the laboratory and the field.

An intimate relationship exists between a honey bee colony and the environment because the workforce primarily forages within 2km of its hive, but occasionally forages up to 6km or more (Eckert 1933, Visscher and Seeley 1982, Wenner *et al.* 1991, Oldroyd *et al.* 1993). Consequently, particles from this 12-110 km^2 area, passively adhere to the branched hairs of individual workers and accumulate within the hive. This natural phenomenon of extensive, environmental sampling puts the colonies at risk of pesticide poisoning. Yet, it also centralises the colony's response to these toxic events and allows us to monitor their recovery and possibly identify the effects this may have on the surrounding environment.

To date, research on the effects of pesticides on honey bees is predominantly based on toxicity assays determined using small samples of caged bees (Johansen *et al.* 1990). The experimental end points, LD_{50} values[1], of these studies may be inappropriate for the field as captive honey bees behave differently to those from established colonies. The LD_{50} values do not account for field variables nor inform beekeepers and scientists of the effects that pesticide exposure has on the recovery of the colony, pollination effectiveness, or honey production.

The toxicity of a pesticide to a colony is typically evaluated by counting dead bees. This classical method analyses pesticide residues in relation to mortality (Atkins and Kellum 1978), and is able to retrospectively identify detrimental events for further analysis. Like the toxicity assays, dead bee counts do not provide a "real-time" holistic view of the colony's initial response, or the recovery process, relating to toxic events. The ability to detect the initial stages of colony adversity and hive annulment through "real time" data, increases the accuracy and usefulness of research conducted in the field.

A colony that fails to forage food is unable to replenish its reserves and will only last as long as the food is available. This suggests that flight activity is a good indicator of

[1] LD_{50} is the dose (micrograms per bee) per individual honeybee which is expected to kill 50% of a group of bees in a laboratory.

foraging frequency. The University of Montana (UM) has designed an electronic honey bee counter that counts the number of incoming and outgoing bees. The flight activity of each colony is displayed on a graph and is updated in "real time". Studies completed by UM (Bromenshenk pers. comm.) reveal that a nucleus colony, containing ten to fifteen-thousand bees, makes sixty to eighty-thousand flights per day. This flight activity substantiates why pesticide residues that adhere to bee hair is subsequently transported back to the hive and becomes hazardous as it accumulates. It also justifies why the main exposure to pesticides occur when worker bees forage on treated crops (Johansen *et al.* 1990).

My research studies the response of established colonies to contact exposure of the commonly used pesticide, methyl parathion, by quantifying changes in colony composition and flight activity.

Honey bees

The European or black race honey bees, *Apis mellifera* L. (Apidae), were introduced from England to Northland, New Zealand in 1839 and from Australia to Nelson in 1842. Due to the increased use of Italian queens, after their introduction in 1880 and the 1950 ban of bee imports[2] (Matheson 1997), the Italian race is now predominantly used on a commercial basis, for pollination and high honey production in New Zealand. The Italian race of bees is also common in the United States of America and was used in these studies. Throughout this thesis I will refer to honey bees as bees and identify other *Apis sp.* specifically.

Honey bees are vegetarians, foraging mainly on nectar and pollen from plant blooms, sugar syrup and honey-dew. This highly integrated society of social insects is made up of three castes; queens, drones, and workers. Each caste has distinct body characteristics,

[2] Except for quarantined Italian honey bee semen introduced in the early 1990's to improve New Zealand's bee stock (Matheson 1997).

and developmental stages. A queen may live 1 to 3 years and lay up to 1500 fertilised eggs per day. She achieves this by mating with 7-17 different drones until she has stored 5-6 million sperm in her spermatheca (Matheson 1997). Drones are male bees whose primary function is to mate with virgin queens. Sterile female worker bees make up the majority of the hive and perform tasks associated with their age called "division of labour". These include the gathering and processing of food, caring for brood, regulating hive temperature, and defending their colony. The workers live 4 to 6 weeks during summer, 4-8 during autumn and about 20 weeks during winter (Johansen & Mayer 1990, Matheson 1997).

The body of a worker bee is specially adapted to make it an effective pollinator. Branched hairs, antenna cleaners, and pollen baskets (corbiculae) help the workers collect and transfer pollen to the hive to make bee-bread for larvae. Pollen contains protein, minerals, fats, vitamins and trace elements critical for honey bee growth (Matheson 1997). To rear brood, a commercial colony collects between 15 and 55 kg of pollen each year. A typical 15mg load of pollen is obtained by visiting between 1-500 flowers. This means a colony makes at least 1.3 million foraging trips to collect 20kg of pollen (Matheson 1997).

Methyl parathion

Methyl parathion, (0,0-Dimethyl 0-p-nitrophenyl phosphorothioate) was chosen for these studies as it is USA's most widely used organophosphate insecticide (Bennett *et al.* 1990). This organophosphate was developed as a result of World War II nerve-gas research and is a potent neurotoxic agent that kills insects and other animals by disrupting transmitters in their nervous systems (Lowell 1979, Lyman 1979, EWG 1999). It is used as a pesticide in New Zealand and the United States of America to protect agricultural crops such as apples, peaches, pears, rice, wheat, sugar beet, peas, onions, and cotton.

In the United States of America, a law was passed in 1996 for the Environmental Protection Agency (EPA) to reassess the tolerance levels of hundreds of pesticides by

August 1999. Methyl parathion was included in this assessment because of its toxic effect on the human nervous system. The EPA was directed to apply "an additional tenfold margin of safety" for infants and children as the Environmental Working Group estimates that more than 1 million children consume "an unsafe dose" of organophosphates each day. A "restrictive-use" ban was enforced in August 1999, but of the 1.9 million kilograms of methyl parathion that were applied to 2 million hectares in 1998, 75% of the kilograms and hectares produced cotton, corn and wheat, and these remain unaffected by the ban until the completion of further research. (The New York times 1999).

Two forms of methyl parathion are used to spray crops, emulsifiable concentrate (EC) and a microencapsulated (ME) form, often referred to as Penncap-M. ME was introduced for commercial use in 1974 (Lowell 1979) and was found to reduce the handling risk for applicators because dissipation of the pesticide was slowed by the polymeric capsules, approximately 30 to 50μ in diameter (Barker *et al.* 1979). This increased the residual activity to >4 days in the field, at 0.56 kg/hectare, compared with <1-3 days for the same EC dose (Johansen *et al.* 1990). Numerous studies confirm that residual action determines whether a pesticide can be safely used on blooming crops because as the residual activity increases, so does the risk to honey bees (Johansen 1979). Anything less than 8hrs is of minimal concern as it can be applied at night, whereas pesticides with residual times longer than 8hrs are not safe to use (Johansen *et al.* 1990). The capsules, similar in size to pollen grains have been proven to adhere to branched bee hairs, transported back to the hive in the corbiculae, and stored in the pollen reserves for up to 7 to 14 months (Burgett & Fisher (1977), Stoner *et al.* (1978), Lowell 1979, Willis 1992). Delayed breaks in brood cycles were seen from season to season as the bees that ate this contaminated pollen died.

Despite the hazard of ME methyl parathion to bees, it continues to be used because the benefit of lowering the acute toxicity to humans, without lowering its effectiveness, has increased the benefit-risk ratio (Lyman 1979, Lowell 1979). Laboratory studies by Atkins and Kellum (1978) showed that a dusting of the EC formulation was twice as toxic to honey bee workers than the encapsulated formulation, but the residue of ME persisted

four times longer. This supported field observations where workers foraging ME were able to make double the number of trips, than those foraging EC, before they accumulated a lethal dosage that consequently affected the entire colony. It is now confirmed that when bees forage sprayed areas, colonies are readily destroyed or damaged by encapsulated methyl parathion and that it is too hazardous to apply to any area at any time when bees are within 1.6km of the treated area (Barker *et al.* 1979). For this reason, and the fact that results could be observed immediately, a soluble solution of 99% methyl parathion mixed in methanol was used in these studies.

The hives used in this thesis differ from standard bee keeping equipment to enable flight data recording as well as effective brood nest sampling, quick identification of queen presence, and easier hive relocation. The following explanations describe this equipment and the terminology used to define it.

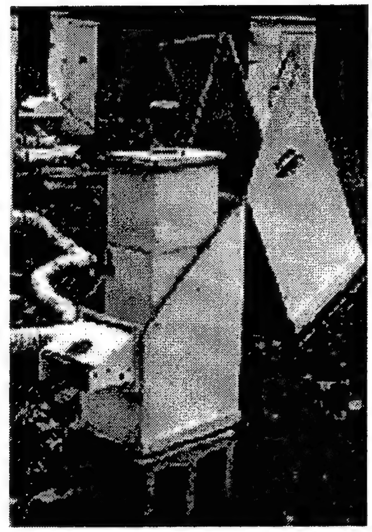
Nucs

A nucleus colony, or "nuc", is a small colony that occupies less than a standard hive box, 505 x 405mm. A nuc hive is a small box used to house a nucleus colony (Matheson 1997). In this thesis the term "nuc" refers to a colony consisting of 10-15,000 honey bees which is approximately twenty-five percent of a commercial sized colony. A nuc hive, (fig. 1.1.), is a stack of two hive bodies, each 230mm x 270mm x 240mm, containing five, half-sized frames (205mm x 190mm) of drawn comb[3].

[3] The honey bees have formed hexagon-shaped wax cells on a synthetically produced wax foundation that is fitted inside each frame.

Figure 1.1. A two-storey nuc hive that consists of five frames of wax comb. The metal tool on the top of one hive-body is used to pry the frames apart.

Figure 1.2. A condo containing a nuc hive. The bee counter is positioned on the front of the condo and is marked with a black circle.



Condos

The name "condo" refers to the shell, that surrounds experimental nucs (Fig. 1.2.). The bee counter attached to the front of the condo consists of 14 tunnels that determine the number and direction of the bees entering and exiting the hive by light sensors (Fig. 1.3.). The data are processed at thirty-second intervals by computer software designed by the UM team. Two temperature probes were placed between the hive bodies nearest the brood nest, to record temperature data that were processed at five-minute intervals. The front doors of the condo open and the top portion hinges back to reveal a stack of three plastic boards supporting a nuc hive that is positioned toward the back. The nuc covers a large hole beneath which a trough-shaped dead-bee trap is situated. The front, back and side walls are made of glass, and the base is part wood, part screen (Fig. 1.4.). Below the screen is a dish to collect pollen when a pollen-excluder[4] is inserted between the hive and the top plastic board. The front section of the middle plastic board is non-existent as this creates a passage that leads to the 14 tunnels of the bee counter.

[4] A pollen excluder is a sheet with holes that are the same size as a forager bees body. When the worker returns from foraging and goes through these holes, the pollen is knocked out of the corbiculae.

Figure 1.3. The condo entrance consisting of 14 tunnels.

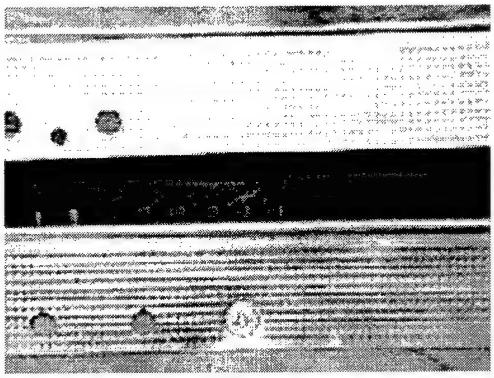
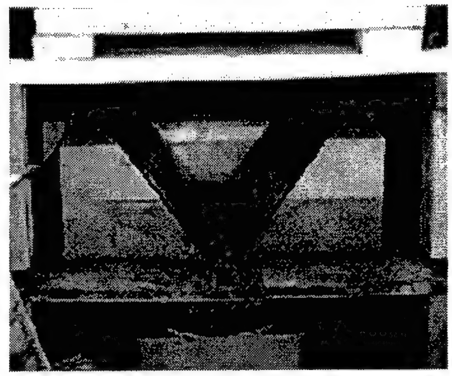


Figure 1.4. The plastic entrance at the front of the condo situated above dead bee trap.

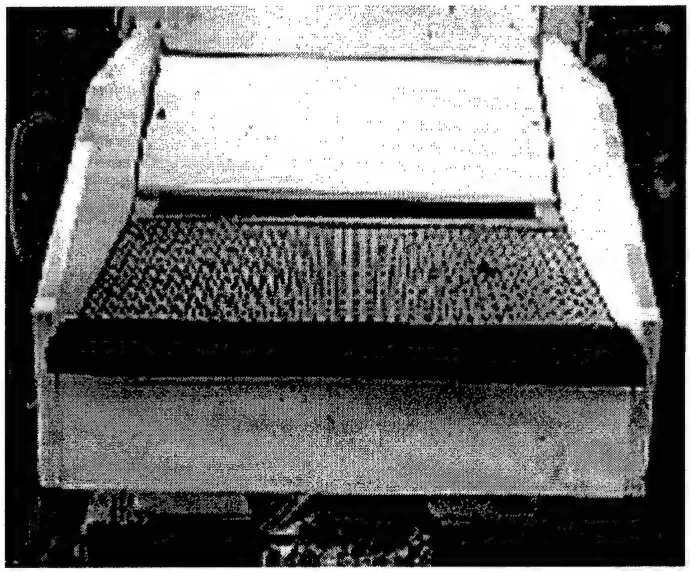


Application Porch

To quantify the effects of contact exposure to methyl parathion on the hive dynamics of *Apis mellifera* (Chapter 4), I designed an application porch that would simulate contact exposure to crop spraying. The porch (380mm x 290mm) was fitted to the front of the counter and contained a shallow well (268mm x 192mm x 20mm) with grooves in the base to create air currents. A perforated metal-screen with folded sides fitted into the well and sat flush with the porch (Fig. 1.5.). The treated filter paper was placed on this screen and the methyl parathion volatiles were extracted by a vacuum system of metallic stretch pipes containing an organophosphate filter that was attached to the base of the well. This ensured only bees outside the bee counter made direct contact with methyl parathion and those inside the hive were indirectly exposed through them. The porches were covered to minimise the effects of rain, wind, temperature, sunlight and relative humidity that all affect the rate of pesticide disappearance (McDowell *et al.* 1987).

A plastic sheet was placed on the ground beneath the porch to collect the dead bees that had been removed from the hive or may have died before entering.

Figure 1.5. The application porch that attaches to the bee counter on the front of the condo. The treated filter paper was placed on the perforated metal screen that the bees were required to walk over to get into the hive.



Methyl parathion is known to kill bees but the quantitative effect that it has on colonies and ultimately pollination is unknown. The impact of pesticide spraying near *Apis mellifera* colonies is embedded in the time of application and associated with the flight dynamics specific to a location. The aims of this thesis were: 1) To identify and quantify changes that occur in honey bee colonies as a result of an application of methyl parathion. 2) To determine if and how the colony returns to a status quo, and whether the hive can continue to be used for bio-monitoring, pollination and honey production once they have been exposed to methyl parathion. The experiments were based on the hypothesis that honey bee colonies dosed with methyl parathion become an ineffective foraging force that consequently decreases pollination.

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Chapter 2: Can Electronic Systems Detect Toxic Events That Occur In *Apis mellifera* Colonies?

ABSTRACT

An electronic honey bee counter, designed to record the number of bees entering and leaving the hive, enables toxic events to be detected when they occur in *Apis mellifera* colonies. Classic dead bee counts showed that doses of 100mg, 250mg and 500mg of methyl parathion had an immediate effect on the colony. The flight data collected by the counters supported these results, and also enabled the progression of colony-recovery to be observed in "real time".

INTRODUCTION

In the United States of America accidental honey bee mortality was first attributed to pesticides during the 1870s, but remained unproven until fruit trees in bloom were sprayed during 1889 to 1896 (Johansen, 1977). Intentional treatment of blooming crops is now rare but bee poisoning still occurs when weeds on the edges of crops are contaminated whilst in bloom (Barker *et al.* 1979).

Lethal dosages of insecticides commonly cause excessive build-up of dead and dying bees at the hive entrance. Further symptoms include aggressiveness, stupefaction, paralysis, back spinning and abnormal rapid or jerky movements (Johansen 1977 & 1979, Barker *et al.* 1979, Atkins *et al.* 1992). Organophosphate insecticides also induce workers to regurgitate nectar from their honey sacs. This leaves the hives sticky and causes the workers to die with their tongues extended. Ultimately, the queen may cease to lay eggs in response to a declining workforce (Johansen 1977, Barker *et al.* 1979).

Effects of acutely toxic insecticides to pollinators are observed more frequently than are the effects from doses labelled as "sublethal" (Tasei *et al.* 1994). However, under certain circumstances the latter are just as detrimental to honey bees, and have been confirmed to cause death, reduce learning power and pollen collection, cause

fecundity and lifespan to decline, produce abnormal larval and pupae growth, and alter genetic fingerprints (Moriarty 1969, Robert *et al.* 1989, Tasei *et al.* 1994). Studies by Schricker and Stephen (1970, 1974a, 1974b) show that sublethal doses of parathion also cause foragers to make communication mistakes regarding distance and timing for feeding sites.

The hazards of pesticides to bees have been assessed through numerous methods. Anderson *et al.* (1971) used a combination of dead bees at the colony, colony strength, bee visitation, and caged bees. Clinch (1971) collected bees from treated crops with a vacuum, whereas Johansen (1977) exposed laboratory bees to field-weathered residues on foliage samples from treated crops. Smirle *et al.* (1984) proposed a standardised bioassay, from 17 references, that considered worker bee age and the environment, and Atkins (1992) used acute and chronic feeding tests.

All of these assessment methods analyse the effects of pesticides retrospectively and several correlate acute mortality with the presence of pesticide residue (LD_{50}) in the laboratory. These methods are ineffective for preventing hive annulment because the analysis occurs after the toxic event has impacted the colony. Applying laboratory results to the field is often inappropriate because sublethal exposures of the pesticide are not accounted for in the laboratory. Secondly, methyl parathion residues, found on dying bees, vary from zero to excess of the lethal dosage within a single experiment (Barker *et al.* 1979, and Melksham *et al.* 1981, Smirle *et al.* 1984). Correlating field trial results with those from the laboratory may also be confounded by the fact that foragers poisoned by fast-acting compounds do not often return to their hive (Johansen 1977).

To identify the effects of pesticides on field colonies, as well as the direct effect on forager bees, we require parameters that can be quantified as these changes occur. MacKenzie and Winston (1989) previously suggested that foraging activity may be of some use, but until now, the number of bees leaving and entering a hive has been impossible to manually record (Pearson 1983). However, the development of the bee counter has enabled 60-80,000 flights that were made by a single nuc, on one summer day, to be recorded (Bromenshenk *pers. comm.*). Based on this class of data, the counter system may be able to actualise the usefulness of a "foraging" parameter.

Flight activity is susceptible to biotic and abiotic factors which complicates the usefulness of this parameter. Weather, light availability, and temperature, influence the foraging activity of bees and also determine the effectiveness of methyl parathion in the field (Crosby 1972, Spencer *et al.* 1973, Johansen 1979, Harper *et al.* 1983, Willis & McDowell 1987). Long, sunny days induce flight activity and maximise pesticide impact. Conversely, short, wet and windy days suppress flight and inhibit pesticide effectiveness. In order to use flight data when determining the effects of pesticides, it is essential for the electronic system to discriminate flight data from daily weather patterns.

The purpose of this study was to determine whether bee counters attached to *Apis mellifera* hives could detect colony response to a toxic event, and whether they could be used to monitor the colony's recovery, with the prospect of preventing hive annulment. Identifying deviations from the basal rate of "real time" flight data was the technique used to assess this.

METHODS

Study area and sampling methods

The experiments were conducted in an apiary at Fort Missoula, Missoula, Montana, United States of America. Approximately 7km east of Forte Missoula, a second apiary at West Campus was used to isolate untreated, and later treated, hives. Missoula is a valley that is 981m above sea level and is surrounded by five mountains. It experiences an average summer high of 28°C, compared with a winter low of -10°C (Microsoft 1994).

Packages of Italian-race honey bee workers weighing 0.9 kg, each with approximately 10,000 workers and a mated queen, were obtained in April 1998 from an apiary in Western Montana, and then established in individual nuc hives.

Experiment 1

Vapour-exposure experiments by Boelter and Wilson (1984) showed volatile methyl parathion was released from contaminated pollen at both 10mg and 500mg concentrations. Because we were testing the ability of the system to detect acute toxic events, rather than the effect of different pesticide concentrations on the colony, we dosed two colonies with a 250mg concentration of methyl parathion, and two with a 500mg concentration. Seven nucs were selected for this experiment in early July 1998, and randomly placed in the condos at Fort Missoula. Each nuc was queen-right[1], and contained eggs, larvae and capped brood. Two of the seven colonies swarmed[2] on the 9th of July and one did not recover to the required experimental criteria in time so it was rejected from this experiment. Three days prior to the treatment, the colonies were checked to ensure they were still of similar size and composition, and then the queen was caged in the centre frame of the lower hive body, to prevent experimental damage. Two of the six remaining colonies were used as controls, two were dosed with 250mg, and two with 500mg of methyl parathion.

On 20th July 1998, 19.03g ± 0.02g of freshly collected pollen was measured into six treatment beakers, and 0.165ml of ethylene glycol, which is non-toxic to bees at low doses (Standifer 1972, Moffett *et al.* 1973), was added to each as a surfactant. Methanol was used to dissolve the 99% concentrate methyl parathion supplied by Radian International, USA, and 8 ml of methanol containing the specified amounts of methyl parathion were mixed with the pollen and spread onto plastic petri dishes containing drawn comb. The treated pollen was tamped into the cells with individual metal rods and sealed until application at 10am.

The vapour density of methyl parathion is 9.1 times denser than air, 10.8g/l compared with 1.186g/l respectively (Appendix 1). To allow the vapour to filter throughout the hive, without the bees directly contacting the treated pollen the petri dishes were placed upside down on the top screen of their allocated hives. The hive lid was replaced and the dead bees were cleared from the dead bee trap. Subsequent

[1] Queen-right means the colony has a laying queen.

[2] Swarming is when a group of workers and drones leave their hive, with the queen, to establish a new colony. The remaining workers continue to raise the new queen that has already been developing in a queen-cell.

collections were at 10pm each evening from 17th to 29th July. The flight data were recorded from 6am to 10pm by the computer system.

The treated pollen was removed from the tops of the hives five days after treatment. On the 29th July the status of each colony was determined and then the queens were released once the bees had been moved to the West Campus apiary. Ten hours later, seven new colonies were introduced to the condo hives to ascertain whether a new colony would be affected by pesticide residues in the previously dosed hive.

Experiment 2

A second experiment was designed to evaluate the system's ability to detect and monitor toxic events for various strength colonies. A weak colony (containing six or less frames of bees) and a strong colony (greater than eight frames of bees) were dosed with 100mg of methyl parathion. A second set of colonies was dosed with 250mg, and a third set was used as experimental controls.

On 6th August 1998, the same methods were employed as in experiment 1 except: Dead bees were collected but their numbers were not analysed for this study; 16.60g ± 0.01g of pollen was combined with the methyl parathion, instead of 19.03g ± 0.02g; the queens were not caged, just restricted to the bottom hive body by a queen excluder; and a second group of colonies were not introduced to the dosed hives. The methyl parathion treatments were removed 15 days after treatment and the hives were taken to the West Campus apiary.

Data analysis

The dead bees from each hive were collected and tabulated. The extent of mortality was categorised using Atkins *et al.* (1970) values that were determined using Todd dead bee traps[3]. Normal mortality for a commercial sized hive is less than 100 bees per day (Atkins *et al.* 1970). A low kill is considered 200-400 dead bees, 500-900 is moderate, and more than 1000 bees per day is a high kill. With these data as a basis, the results from each dose were averaged and the standard errors, where SE = $\sigma/\sqrt{n}$

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[3] A Todd dead bee trap is a modified wooden hive base. The base has angled slats that the dead bees fall through onto a removable board for their collection.

(Martin *et al* 1993) were calculated. Any number greater than 100 was considered abnormal. The dead bee data were graphed using version 4 of the program Deltagraph.

The flight data from both experiments were analysed by colour mapping the total number of incoming and outgoing bees. The six bars of the colour map represent the six hives and each is read in two dimensions. Successive days are added to each bar from top to bottom, whereas the duration of the day is represented by the width of the bar, from left to right. The hotter colours denote greater flight activity. These Deltagraph colour maps were used visually to compare the colony response to dosages of methyl parathion in order to determine the usefulness of the bee counters for collecting flight data. Colourmaps from experiment 2 were used to identify any possible effects related to pesticides, that could be attributed to colony size.

RESULTS

Experiment 1:

The average dead bee counts obtained from the dosed hives two days prior to colony treatment are presented in Table 2.1. Mortality returned to normal on day 2, but all colonies were affected by the introduction of the treated pollen at t_0 (Fig. 2.1). Six hours later, the four colonies treated with methyl parathion were obviously irritated and those dosed with 500mg hung in a beard formation on the front of the hive for the first two nights. High bee kills were collected from both the 250 and 500mg hives for these first 36 hours post-treatment, and then moderate kills were obtained from the hives up to 156 hours. Low kills were collected from the 250mg set of hives until they were removed from the condos at 228 hours, whereas the 500mg set had low mortality until 204 hours, which reduced to normal by 228 hours.

Flight activity was inversely proportional to dead bee data because as it decreased, bee mortality increased. At the beginning of the experiment all six hives were making between 75 – 90,000 trips per day (Fig.2.2). On dose day, day 3, the flight activity of the four methyl parathion treated hives dropped to less than 60,000 flights per day, and by 84 hours had declined to less than 40,000 flights per day. The first control

colony exhibited more than 90,000 flights per day at the start of the experiment, whereas the second control made 65,000 flights per day. By the end of the experiment the activity of the first control had declined to 65,000 flights per day and the flight activity had increased 90,000 flights for the second control.

All six queens, surrounded by a small amount of brood, survived experiment 1.

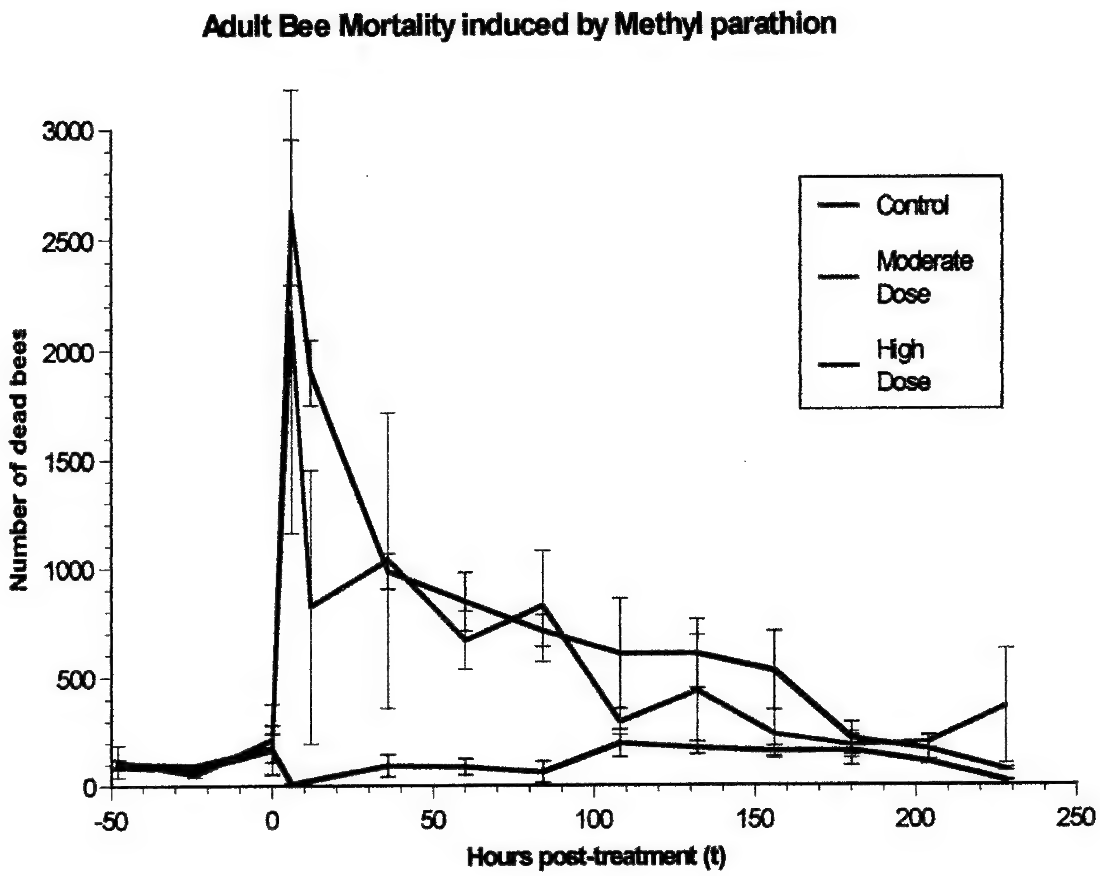
The replacement colonies that were introduced to the control hives, and the hives dosed with 250mg, did not appear to be affected by methyl parathion residues. However, moderate and low dead bee counts were obtained from the colonies that were introduced to the hives previously dosed with500mg hives (Table 2.1.). Because sample size (n) was only 2, the standard errors of the dead bee data varied from 9 to 1008 for the results from within a colony. Between colony variance ranged from 1.5 to 1008. The results were not analysed further because the standard error suggests the statistical accuracy would be small.

Table 2.1. The mean number of dead honey bees collected from colonies that were treated with pollen dosed with 250mg or 500mg methyl parathion, during July 1998 in Missoula, Montana, United States of America. N = 2. SE = Standard Error.

Day	**Hours Post-Treatment (t)**	**Control**		**SE**	**250 mg**		**SE**	**500 mg**		**SE**
		Methyl parathion dosage								
1	-48	87	n	4	115	L	75	106	L	18
2	-24	75	n	16	51	n	**9**	94	n	2
3	0	168	L	113	215	L	163	177	L	66
3	6	10	n	**1.5**	2169	h	**1008**	2624	h	**327**
3	12	26	n	1	825	m	630	1899	h	148
4	36	95	n	51	1038	h	679	985	h	81
5	60	88	n	37.5	669	m	132	847	m	134
6	84	64	n	50.5	825	m	255	712	m	73
7	108	197	L	62.5	295	L	59	608	m	250
8	132	175	L	28.5	438	m	256	606	m	157
9	156	159	L	26	238	L	112	529	m	180
10	180	164	L	70	188	L	59.5	218	L	75
11	204	109	L	9	203	L	29.5	167	L	63
12	228	22	n	1	365	L	262	73	n	6
		Replacement colonies								
13	262	101	n	15.5	49	n	18	404	m	56
14	286	61	n	9.2	59	n	19.5	204	L	37
15	310	67	n	6	41	n	17	110	L	42
16	334	48	n	20	19	n	4.5	128	L	1.5

n = Normal L = low kill m = moderate kill h = High kill

Figure 2.1. Average number of dead honey bees collected from the three treatment groups each evening. The colonies were dosed at t_0 where the high dose was 500mg of methyl parathion and the low dose was 250mg.



Experiment 2:

The control colonies began the experiment making 90,000 and 60,000 flights per day. The larger one declined to 65,000 and the smaller one remained consistent, so at culmination they were both making approximately the same number of flights per day (Fig. 2.3). The two strong hives dramatically reduced their flight activity after 60 hours (8th August). The flight activity of the strong colony that was dosed with 250mg declined from 90,000 to 40,000, whereas the strong hive treated with 100mg finished the experiment with the highest activity of 50,000 flights, out of those dosed with methyl parathion. The flight activity of the weak colonies declined from 55,000 for the 100mg dose, and 30,000 for the 250mg dose, to 30,000 and 20,000, respectively.

Figure 2.2. Flight activity of six similar sized honey bee colonies recorded by electronic bee counters. Two hives were dosed with 250mg of methyl parathion and two hives were dosed with 500mg of methyl parathion on day 3. The hotter (red and yellow) colours denote greater flight activity.

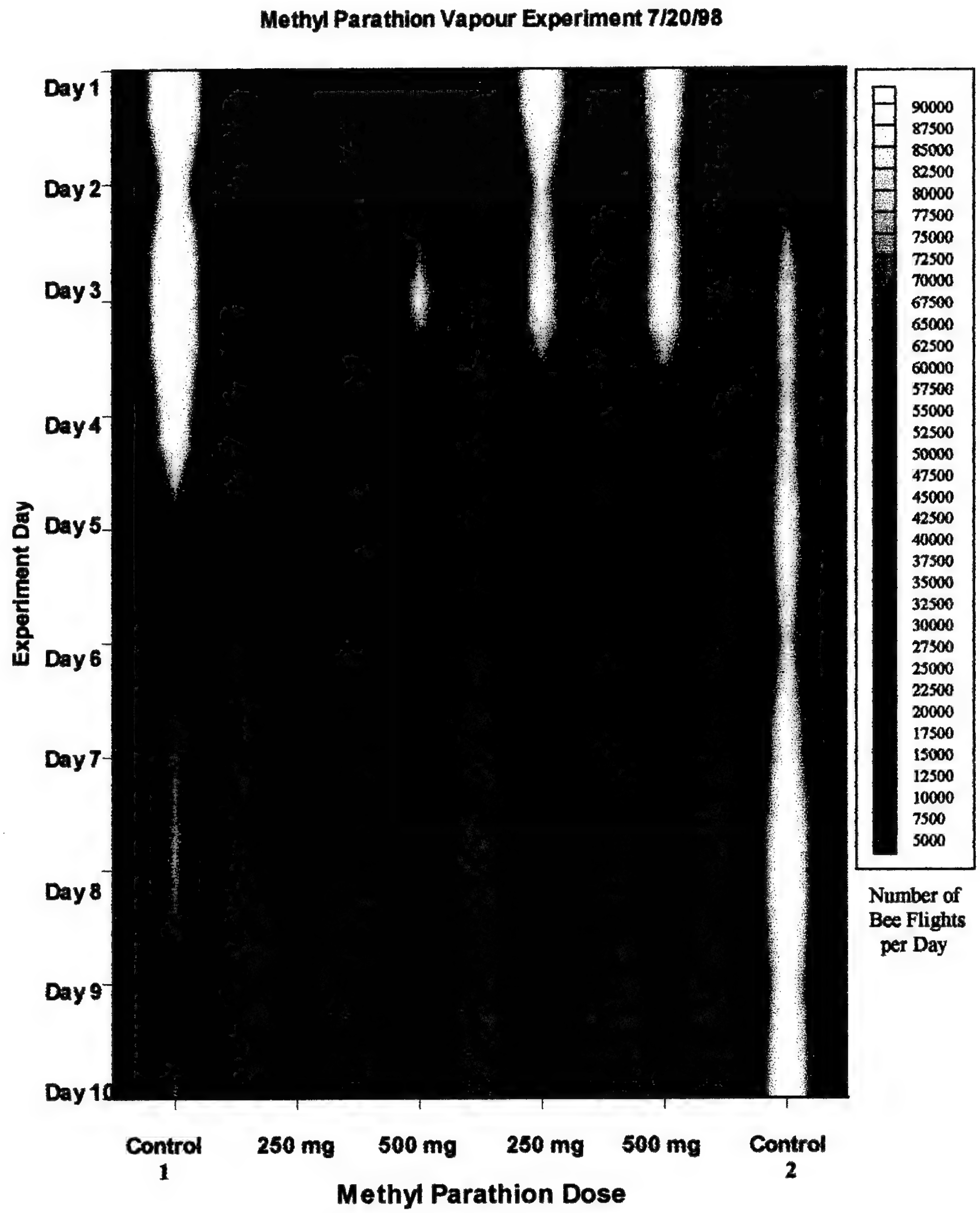
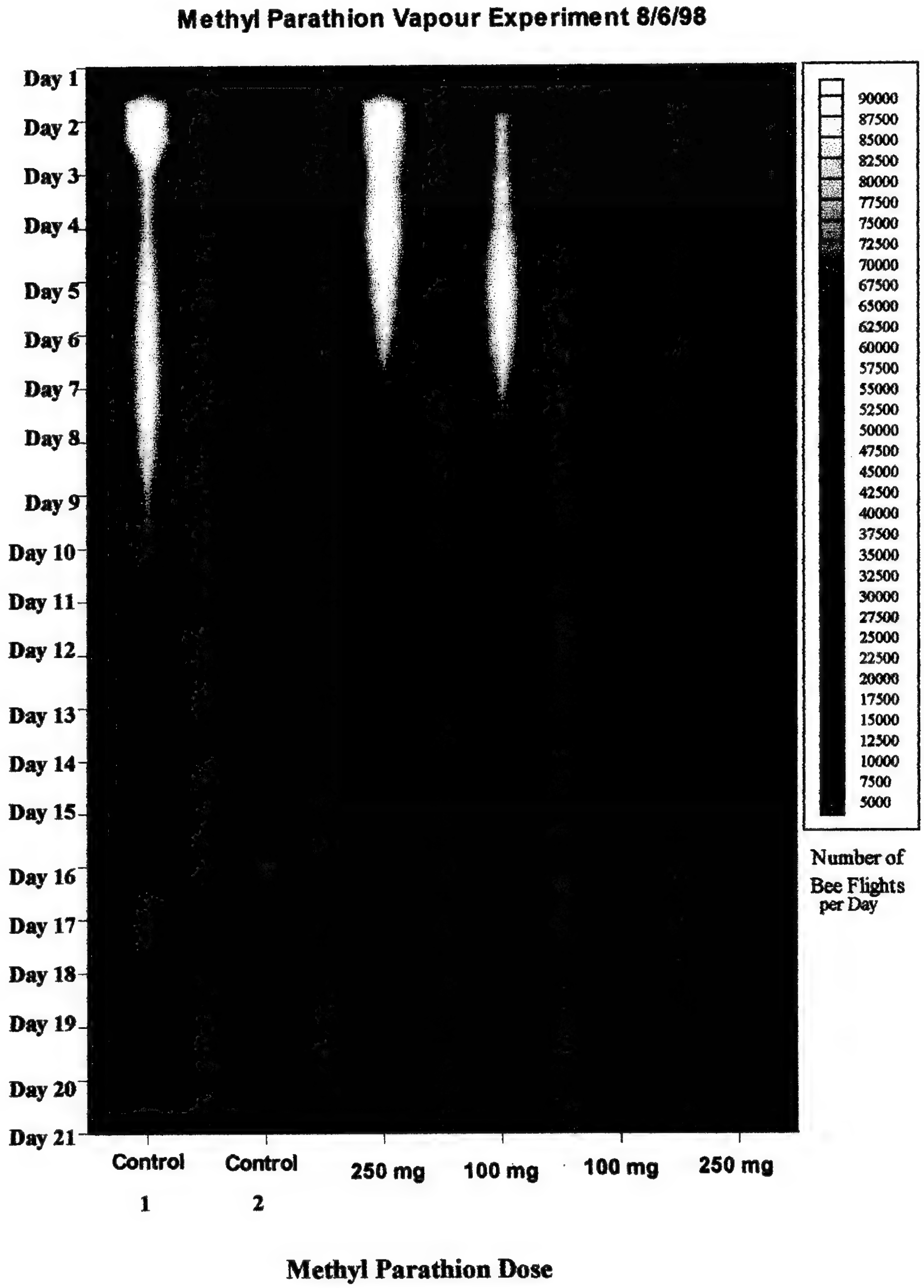


Figure 2.3. Flight activity of three small honey bee colonies and three large colonies, recorded by electronic bee counters. The three small colonies are positioned in places 2, 5, and 6, reading from left to right. Two hives were dosed on day with 100mg of methyl parathion and two hives were dosed with 250mg methyl parathion on day 3. The hotter (red and yellow) colours denote greater flight activity.



DISCUSSION

The "low" bee mortality seen at the start of experiment 1, was expected as this commonly occurs when hives are relocated, or when hive checks have been made. These results can probably be attributed to the hive checks that were made on the 17th July. For future experiments, to allow the colonies to acclimatise to their surroundings, and for colony mortality to return to normal, hive checks and the relocation of hives to condos, should be made approximately three days before the treatment, or as far in advance as possible without decreasing the reliability of the colony status check.

The dead bee collections clearly identified the initial mortality caused by methyl parathion. This supports the literature that deems this parameter as a useful first indicator of colonies exposed to pesticides (Johansen 1977). However, the usefulness of this parameter does not extend beyond the initial identification because the number of dead bees declined each day, post-treatment. This decline of dead bees does not indicate that the colony has recovered but merely that fewer bees were dying. This became obvious when the mortality counts from the colonies that were dosed with 500mg had returned to normal by the conclusion of the experiment, yet only a small population remained in the hive. However, flight activity data supported the hive checks. The flight activity from the treated colonies declined each day post-treatment, indicating that the forager forces had declined and that the hives had not yet recovered. This inversely proportional relationship between flight activity and dead bee counts authenticates flight activity as a more accurate parameter, than the dead bee counts, for indicating the colony status over time. Consequently, dead bee counts were not analysed in experiment 2.

The first control colony exhibited more flight activity at the start of the experiment than the second control, but this declined by the end of the experiment. The flight activity may have been greater simply because it was a more active hive, and not because it was a larger population (Bromenshenk pers. comm.). Contrary to this, the control colony may have robbed energy supplies from the hives that were weakened by the methyl parathion doses and this may have killed some of its foragers.

Throughout the experiment the bees appeared to display selective behaviour. As the flight activity of the treated colonies dwindled, the flight activity of the second control colony appeared to gain workers because the flight activity increased. This control was positioned two meters from the 500mg-treated hive, which may suggest that if bees return to their hive and it is unfavourable, they will endeavour to join a neighbouring hive that is unaffected. This is contrary to the literature which states bees are loyal to their colony (Johansen 1977).

The irritation and clustering behaviour displayed by the colonies that were exposed to methyl parathion are classic responses exhibited by honey bees when the temperature outside their hive rises above 21°C (Atkins *et al.* 1977). It is not known what caused the bees in this experiment to hang on the outside of the hive at night, but there are two possible explanations. Firstly, the concentration of the pesticide may have caused a suffocating effect strong enough to drive the bees out. Secondly, as the bees have tried to remove the vapours from the hive, the increased activity has increased the hive temperature. When hive quality deteriorates by predation, fire, pests, over-heating, or pesticides, the expected response is for the colony to abscond (Fletcher 1975-76, Winston *et al.* 1979, Schneider 1990). However, the colony did not abscond because the queen was caged, and even though the majority of the colony hung outside the hive for 36 hours, due to unfavourable conditions, the queen survived. This suggests the colony was able to adjust to the hive atmosphere or manipulate it to become tolerable.

The hives that were initially treated with 500mg doses of methyl parathion contained residues that caused the replacement colonies to experience moderate to low bee mortality. This is thought to be the result of the beeswax comb absorbing methyl parathion vapours (Boelter *et al.* 1984). Residue levels are effected by numerous factors (Melksham *et al.* 1985), so to prevent any unknown contact with methyl parathion, future experimental colonies should be allocated to hives that have not been in contact with pesticides.

Experiment 2 showed that the electronic system could detect differences in hive size and revealed that even though the workforce of large colonies were more seriously affected than those of smaller colonies, larger colonies had a better chance of

recovering from toxic events. This is because they have more foragers to be exposed to the pesticides, and this often results in up to four times more mortality (Johansen 1979, Johansen *et al.* 1990). Once initial mortality occurs the colony suffers no additional loss of adult workers as few or no bees forage until new bees emerge (Johansen *et al.* 1990). To compensate for the decline in the workforce, young bees are then forced to forage earlier than the usual three weeks after development (Sanford 1983). Because the queens in experiment 1 were confined to a small area for 13 days, they were unable to lay sufficient brood to compensate for lost workers. As a result, the colonies had significantly reduced workforces and the hives contained only small amounts of brood at the conclusion of the experiment. Since the experimental methods had altered colony behaviour and prevented the analysis of colony recovery, the queens were not caged during ensuing experiments.

In conclusion, the University of Montana's electronic bee counter system can detect, and suitably monitor, acute toxic events. These "real time" flight data have enabled the progression of field experiments to be observed and for timely modifications to be implemented. Studying changes in the flight activity of bee colonies in "real time" is an important step towards protecting hives from colony poisoning. It is probable that such data will enable techniques to be devised that will prevent severe crop losses due to lack of pollination.

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Chapter 3: Contact Response of *Apis mellifera* to Methyl Parathion

ABSTRACT

Experiments were designed to determine whether *Apis mellifera* would accept or avoid direct contact with methyl parathion that has been applied to filter paper. Presence/absence observations were used to identify that bees initially avoided direct contact with methyl parathion, but the least disturbing exposure duration was thirty minutes after treatment as the initial avoidance response had dissipated.

INTRODUCTION

Application drift, volatilisation and wind erosion of residues often cause humans, animals and plants to become unintentionally exposed to pesticides (Spencer *et al* 1973, Lewis *et al.* 1976, Seiber *et al.* 1980). Pesticides kill honey bees through direct contact, stomach poisoning, and fumigation (Atkins 1992). The vapours are absorbed through the respiratory system, stomach poisons are absorbed through the alimentary canal, and contact poisons are absorbed through the integument.

Pesticide uptake by honey bees, and how they affect the colony, is influenced by meteorological conditions, formulation, chemical properties of pesticides, and application methods (Taylor 1979, Lyman 1979, Seiber *Et al.* 1980).

The exposure-surface of a pesticide needs to be considered when designing the method of application because it alters the effect on honey bees (Mayland & Burkhardt 1970). Numerous surfaces including glass (Way & Synge 1948), grease-proof paper (Jones & Connell 1954), and filter paper (Beran & Neurer 1956, Beran 1958 & 1963), have been used to study these effects. No specific surface material has been recommended for simulation of field conditions in the laboratory since 1970 because bee mortality counts from treated leaf-surfaces are inconsistent and do not allow for comparisons to be made between glass, and plastic surfaces (Mayland & Burkhardt 1970). However, Mayland and Burkhardt (1970) were able to conclude that volatilisation of toxic chemicals was unaffected by the type of absorbing surface.

Based on these studies, experiments were designed to determine whether *Apis mellifera* would accept or avoid direct contact with methyl parathion when applied to filter paper. Presence/absence observations were used to identify whether the bees would walk on the methyl parathion saturated filter paper, as well as determining, after the paper had been treated, the least disturbing exposure duration for the bees.

METHODS

Mated queens and their associated 0.9kg packages of Italian-race honey bees, were transported in April 1999 from Georgia, United States of America, to Edgewood, Maryland where they were established as nucs.

Only forager bees were used in this experiment because the majority of pesticide poisoning occurs when worker bees forage in treated crops (Johansen *et al.* 1990). A second reason was because older bees are more susceptible to methyl parathion than younger bees due to their lower brain concentrations of acetylcholinesterase (AchE). This enzyme is required to hydrolyse the neurotransmitter, acetylcholine, which is blocked by methyl parathion (Koch 1958 & 1959, Ladas 1972, Mayland *et al.* 1970, Nazer *et al.* 1974).

As the foragers returned to the front of the hive they were collected in a wire cage that was covered to reduce light. A wooden frame (470mm x 376mm x 51mm), covered with wire screen on the base and lid (Fig. 3.1), was used to dose the bees. The enclosure was divided into a 3 x 4 grid, of 120 x 112mm squares. Between the squares was a 4mm diffusion buffer and for each trial a new piece of filter paper was placed on each of the 12 sections.

250mg of 99% pure methyl parathion was dissolved in 25ml methanol and then mixed with 7.825l of water to form a solution equivalent to a field application of 0.56kg/hectare. Six squares were randomly chosen and dosed with 20ml of this solution and the remaining six were dosed with 20ml of methanol.

Experiment 1:

The aim of this experiment was to determine whether honey bees would avoid contact with methyl parathion treated filter paper. 100 forager bees were introduced to the dosing-grid, which was covered to calm the bees. After ten minutes the presence/absence of the bees was recorded for each square. The bees were removed and the filter paper was dosed with methyl parathion. 100 new bees were introduced to the enclosure and the presence/absence of bees in each square was recorded at 10, 30, 50, and 60 minutes post-treatment.

Experiment 2:

To remove the possibility that volatiles in experiment 1 may have effected the behaviour of the bees over time (Taylor 1979), sets of 100 bees were exposed to treated filter paper that had been dosed 15, 30, and 75 minutes prior. The bees were covered for ten minutes after introduction to the enclosure, to let them to settle down before recording the squares of filter paper that contained bees. This also enabled determination of the time duration since the paper had been dosed, that caused least disturbance to the bees.

RESULTS

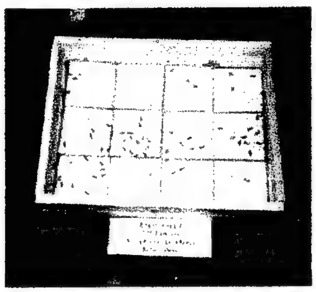
Experiment 1:

The bees that were introduced to the enclosure as soon as the filter paper had been dosed, fanned their wings constantly. Ten minutes after dosing the paper, all the bees were clustered on the left hand side of the screen roof above the treated filter paper (Fig. 3.1.) After 30 minutes the bees had ceased fanning and were seen to be randomly located throughout the entire enclosure as all six treated and untreated squares contained bees (Table 3.1). At 50 minutes the bees were still present in all of the treated squares, as well as five of the six non-treated squares. There appeared to be a preference for the left-hand side, so the enclosure was turned 180 degrees in azimuth. At the end of 60 minutes the bees were dispersed more evenly across all of the squares, which may suggest the left-hand side was preferred. However, the bees

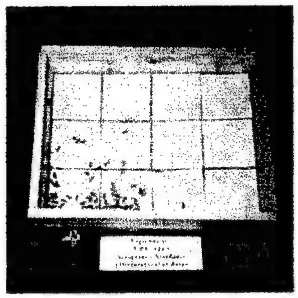
did not appear to be averse to the methyl parathion. This experiment was repeated and similar results were observed.

Figure 3.1. Methyl parathion acceptance/avoidance experiment where the same set of bees was observed at –10, 10, 30, and 50-minute intervals after dosing the squares of filter paper with 0.56kg/hectare. The squares are labelled from one to twelve across, and down the page. Squares 1, 4, 5, 7, 9, and 10 were dosed.

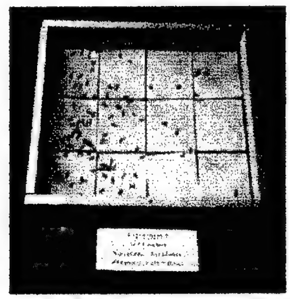
10 minutes pre-treatment:



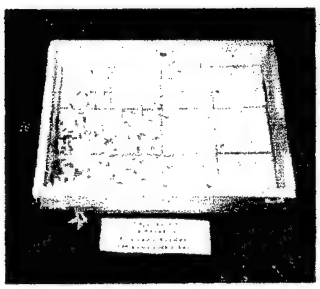
10 minutes post-treatment:



30 minutes post-treatment:



50 minutes post-treatment:



60 minutes post-treatment:

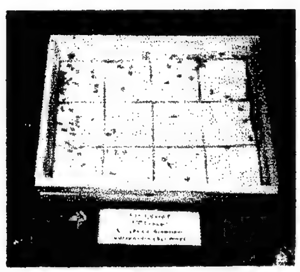


Table 3.1. The presence (P) or absence (A) of 100 honey bees in the 12 grid-squares dosed with methyl parathion at -10, 10, 30, 50, and 60 minutes post-treatment. The presence percentage is included.

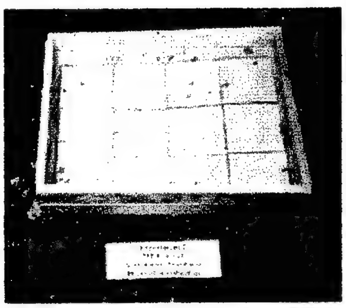
Time of Dose (t_{min})	Presence of honey bees															
	Dosed Squares						Total	%P	Undosed Squares						Total	%P
	1	4	5	7	9	10			2	3	6	8	11	12		
-10	P	P	P	P	P	P	6/6	100	A	P	P	P	P	P	5/6	83
10	A	A	P	A	A	A	1/6	17	A	A	A	A	A	A	0/6	0
30	P	P	P	P	P	P	6/6	100	P	P	P	P	P	P	6/6	100
50	P	P	P	P	P	P	6/6	100	P	P	P	P	P	A	5/6	83
60	P	P	P	P	P	P	6/6	100	P	P	P	P	P	P	6/6	100

Experiment 2:

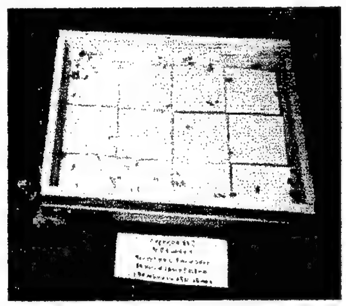
At 15 minutes post-treatment the bees appeared to be avoiding the squares dosed with methyl parathion as they were present on only 2 of the 6 squares (Fig. 3.2.). At thirty minutes the bees were present on all of the dosed squares whereas the bees introduced 75 minutes after dosing the filter paper were located only on three of them. It was assumed that the bees were randomly located in the enclosure after 30 minutes.

Figure 3.2. Methyl parathion delayed introduction acceptance/avoidance experiment. Where three sets of bees were observed at 15, 30, and 75 minutes post-treatment of 0.56kg/hectare of methyl parathion. The squares are labelled from one to twelve across the page, and down. Squares 2, 3, 5, 7, 10 and 12 were dosed.

15 minutes post-treatment:



30 minutes post-treatment:



75 minutes post-treatment:

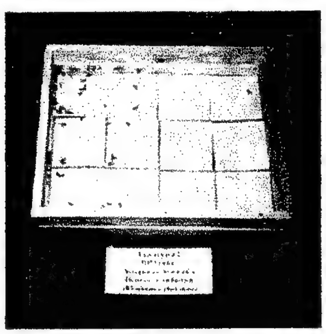


Table 3.2. The presence (P) or absence (A) of three sets of 100 honey bees in the 12 grid-squares dosed with methyl parathion introduced 15, 30, and 75 minutes post-treatment. The presence percentage is included.

Time of Dose	Presence of honey bees					
(t_{min})	Dosed Squares 2 3 5 7 10 12	Total	%P	Undosed Squares 1 4 6 8 9 11	Total	%P
15	A P P A A A	2/6	33	P P P A P P	5/6	83
30	P P P P P P	6/6	100	P P A P P P	5/6	83
75	P A P A P A	3/6	50	P P P A P A	4/6	67

Appendix 4 discusses experimental observations made when methyl parathion treated pollen was placed inside the hive. However, as they were not directly relevant to this thesis they are included for interest.

DISCUSSION

A soluble solution of methyl parathion was used in the experiment as it is less hazardous to honey bees than formulations of dust, wettable powders, flowables, emulsifiable concentrates and soluble powders (Johansen *et al.* 1990).

The avoidance of all 12 squares for the first ten minutes post treatment may possibly be in response to the dampness of the filter paper. The constant fanning of the bees wings over the pesticide has also been recorded (Mayland *et al.* 1970) who said this caused small particles to become airborne and taken into the respiratory system which then led to suffocation. Experiment 1 was not run long enough to see the end results, but it appears the fanning may have helped the treatments to dry quickly and the vapours to disperse because all the bees appeared to be randomly located on the base of the enclosure after 30 minutes post-treatment. Experiment 2 supported results from experiment 1 where the bees appeared to be more randomly located after 30 minutes than at the 15 and 75 minute checks.

Residues predominantly decline by volatilisation for both stable pesticides that have been applied to surfaces, and volatile pesticides (Seiber *et al.* 1979). This could suggest that the methyl parathion volatiles may have produced some unknown effects. To remove this possibility, in future experiments, the volatiles should be extracted using an organophosphate filter.

From this we can conclude that if the dosed filter paper is left to dry for 30 minutes then it causes less disturbance to the colony than immediate exposure to the treated filter paper.

Direct contact was the method of application used for this experiment and since the bees did not appear to avoid the treated filter paper after 30 minutes, this method of application should be employed for future studies.

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Chapter 4: The Effects of Methyl Parathion on the Colony Dynamics of *Apis mellifera*.

ABSTRACT

This study determines the effects on established *Apis mellifera* colonies of two field doses, and the LD_{50} concentration, of methyl parathion. Dead bees, flight activity, percent return of foraging bees, and brood composition were studied to quantify changes in colony behaviour associated with pesticide exposure, and to determine how these changes may impair pollination effectiveness. Flight activity and percent return of *Apis mellifera* declined as a result of methyl parathion, whereas bee mortality increased during treatment and then returned to normal. Brood composition took longer to respond but did eventually decline.

INTRODUCTION

The fact that pesticides kill honey bees has initiated numerous studies to determine how hazardous pesticides are to bees. Pesticide impact is often quantified by the extent of mortality that occurs in small groups of bees exposed to a specified concentration of a pesticide (Smirle *et al.* 1984). Johansen and Mayer (1990) have extensively reviewed specific bee poisoning data for insecticides. They conclude that for any pesticide considered toxic, there is a dose below which it causes no harm. However, because their results are based on laboratory studies they do not discuss the effect that pesticides have on colony dynamics, or how this ultimately effects pollination effectiveness. Even though a pesticide may appear to cause only a low to moderate kill, this may be enough to interrupt pollination, and even hive annulment in the long-term. Consequently, crop yields diminish and this type of long-term loss far exceeds immediate monetary losses caused by bee poisoning (Johansen *et al.* 1990).

Studies that determine the effects of pesticides on the behavioural dynamics of a colony are limited to those that discuss the effects in terms of the entire colony, rather than changes to individual parameters (Melksham *et al.* 1985). Johansen *et al.* (1990) maintain that it is flower contamination that kills bees, not contaminated beehives. However, to determine the true cause of a colony's ineffectiveness or annulment, it is

necessary to identify how pesticide contamination alters the dynamics of honey bees within a colony.

This study determines the effects on established *Apis mellifera* colonies of two field doses, and the LD_{50} concentration, of methyl parathion. Dead bees, flight activity, percent return of foraging bees, and brood composition are the four characteristics studied to quantify changes in colony behaviour associated with pesticide exposure and determine how these changes may impair pollination effectiveness.

METHODS

In this study the effects of contact exposure to specified field applications of methyl parathion were quantified by two methods: Firstly, dead bees and weekly hive composition were manually recorded. Secondly, flight and temperature data were collected electronically.

Eighty colonies of Italian race honey bees, *Apis mellifera,* each with a 1999 laying queen, were established in a stock-group at Edgewood, Maryland. Thirty queen-right colonies, each in a two-storey hive that contained eggs, larvae, capped brood, four frames of honey, and at least seven frames of bees were chosen to form a stock group. A queen excluder was inserted between the top and bottom hive bodies to limit the queen's laying space to the five bottom frames and enable the workers to store honey in the top frames.

The experiments were limited to seven electronic condos (described in General Introduction), and three of these doubled as the controls for an unrelated project. One of the four colonies to be treated was used to determine the appropriate range for the three concentrations of methyl parathion, and identify the duration of colony recovery after being treated with a medium dose. Because the number of sample hives was limited the experiment was repeated three times.

At least 5 days prior to each trial, four colonies of similar sized populations were randomly chosen from the stock-group and taken 18km, NNE, to the Churchville

study site (Fig. 4.1.). This time enabled the bees to sufficiently acclimatise to their surroundings (Moffett *et al.* 1983) and randomly allocated condo, so the dead bee counts returned to normal and a base line for daily flight data was established.

Figure 4.1. Study site set up of six condos and a nuc in Churchville, Maryland, USA. The metallic tubes attached to the porch remove the methyl parathion volatiles through a vacuum system.

The three dose days, "day 4" in the analysis, were August 19, September 10 and September 26. These dates were chosen because nearby crop spraying was complete by late summer/early autumn, and also because the colonies were fully functional in terms of population size, brood production and honey storage.

The LD_{50} value for caged honey bees, $0.11\mu g$ ai[1]/bee (Johansen *et al.* 1990), was used to determine the range of methyl parathion doses for the three test colonies. The LD_{50} value of a pesticide in micrograms per bee can be converted to kilograms of the chemical per hectare, by multiplying by 1.12 (Atkins 1971). The required concentrations of methyl parathion were calculated by scaling the known field applications from kg/hectare, to the size of the application board ($5153mm^2$).

The LD_{50} dose was made by mixing 250mg methyl parathion with 1.727l methanol to form a soluble 0.56kg/hectare stock solution, and then adding 70.9ml of methanol to each 20ml of the solution (Appendix 3). The $0.11\mu g$/bee dose, or 0.12kg/hectare, appeared to have no response on the colony, so the colony was treated with a typical

[1] ai means active ingredient in a pesticide. In this case the ai is 99% concentrate methyl parathion.

field application of 0.56kg/hectare. This caused noticeable mortality and a dramatic decline in flight activity. Based on this, the LD_{50} dose was designated as the base concentration, the 0.56kg/hectare field application was the medium dose, and a second commercial field application of 1.12kg/hectare was designated as the high dose.

The residual toxicity of methyl parathion is less than 3 days (Johansen *et al* 1990), and most of the pesticide loss occurs during daylight hours, 0600 to 1800 (Willis *et al.* 1992). Residual toxicity in the field is also greatly increased by low temperatures at night, which causes a high kill the following day especially when cold nights follow hot days because of the large build up of condensation on foliage (anon, 1975). So to simulate crop spraying, the allocated concentrations of methyl parathion were applied to the filter paper, using a 20ml pipette, on the fourth day of each trial, left to dry for half an hour and then placed on the application porch at 07:00 each morning, for three days. A behavioural reason for removing the treatments from the application board at 19:00, was because bees do not forage in the dark so the pesticides do not affect them at night.

To ensure the behavioural changes caused by the pesticides were the result of contact exposure, the vapours were extracted using an organophosphate filter attached to the base of the application porch. The trials were run for fourteen days in the condos and then the hives were transferred to the stock-site for the continuation of brood composition monitoring.

The effects of the methyl parathion treatments were assessed by quantifying four parameters associated with colony behaviour:

Dead bees: The dead bee traps inside and outside the condo were cleared daily between 16:00 and 20:00. Collecting began 3 days prior to application, until the hives were removed from the condos eleven days later. The dead bee data were normalised using a square-root transformation.

Flight data: The electronic bee counters recorded the number of bees entering and leaving the hive each day, for the fourteen days they were in the condos. The flight

activity of each colony was assessed by a three-step method that enabled the recovery rates of each colony to be determined:

1) The flight data were coded by adding the lowest flight value to each of the data values. This effectively scaled the values up. No square root transformation was required as there was no decrease in variance.
2) The "trial" effect was removed by treating the trials as replications of the experiment.
3) The controls were removed from the analysis so that a direct comparison between the treated hives could be made.

Percent return: To determine the percentage of foraging bees that were returning to the hive after they had been effected by the pesticide, the incoming flight data collected by the bee counters was calculated as a percentage of the bees leaving the hive ((beesIn/beesOut)x100). The data were normalised by a square-root transformation followed by an arcsin transformation.

Colony composition: Weekly hive examinations monitored the changes in hive composition. A wire grid (75mm x 75mm, per square) was used to quantify the contents of the wax cells. There were six grid-squares (33750 mm^2) to each side of a frame, which equates to 1249 cells because there are 3.7 cells for every $100mm^2$ (Harbo 1993). The contents of each square was categorised as either, eggs, larvae, capped brood, pollen, honey, empty or undrawn. ie Frame 2, side A = 2 squares of honey (side A on frame 2 contains 33% honey), 1 pollen square (16.5%), 2 squares of capped brood (33%), and 1 square of eggs (16.5%). Only the combined amount of eggs, larvae, and capped brood were analysed after a square-root transformation had normalised the data. Seven weeks of brood data were collected from the colony that was used to establish the methyl parathion doses. These data were graphed to identify changes in eggs, larvae and capped brood composition, in relation to total brood.

Data analysis

Dead bee counts, hive composition and flight data were analysed by a Repeated Measures, Analysis of Variance, conducted using SPSS Base 9.0 (Statistical Package for Social Scientists). For each of the parameters three tests were used to identify

differences between means of the three trials, differences between the means of the four treatments applied to the hives, and variation that occurred within each hive. These tests were 1)Least Significant Difference (LSD), 2) Sidak, and 3) Student-Newman-Keuls (SNK). The LSD tests were more sensitive than Sidak and SNK so were often selected against to try and reduce the Type 1 error of rejecting the null hypothesis (H_o) when H_o is true. Treatment 1 represents 0.11 kg/hectare, and treatments 2, 3 and 4 represent 0.5 kg/hectare, 1 kg/hectare and the control respectively.

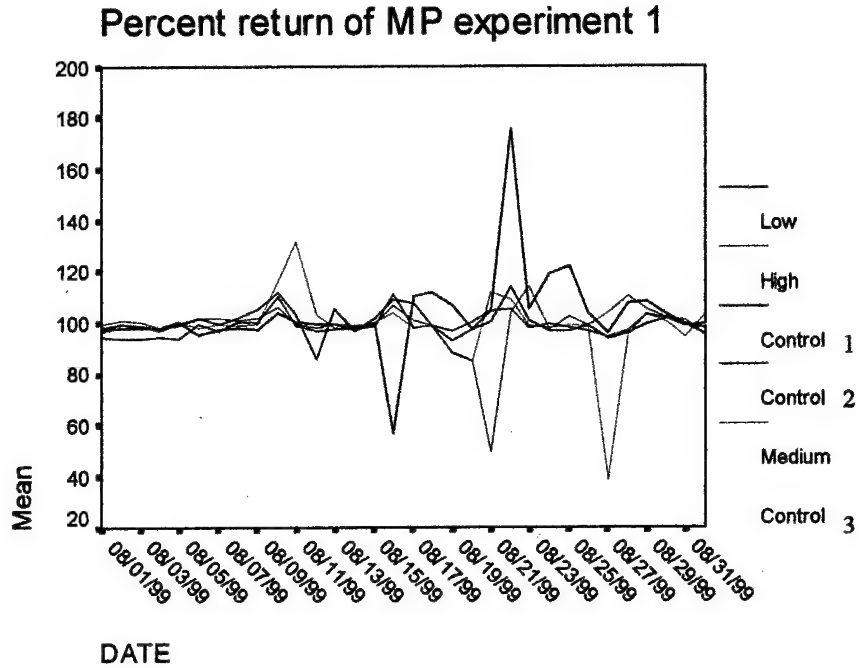
The long-term recovery of each colony was monitored by the hive checks and was visually compared.

RESULTS

One of the three control colonies requeened[2] during the first experiment and then absconded. This colony was rejected from analysis because its behaviour was inconsistent with the other controls, which confounded the analysis as seen in the percent return graph (Fig 4.2.). The inconsistent behaviour is the result of no eggs being layed during the time of queen maturation, which causes the brood nest to shrink and the forager force to decline.

[2] A hive requeens when the present queen has become injured or when her laying capacity has decreased. This occurs either by the development of "supersedure" or "emergency" queen-cells so the hive may go without a queen for up to three weeks.

Figure 4.2. Percent return for the six colonies from trial 1. The line of control 1 appears noisy as a result of the colony requeening. The colonies were dosed on 8/19/99. The low hive received 0.11kg/hectare of methyl parathion. The medium dose was 0.56kg/hectare and the high dose was 1.1kg/hectare.



Dead Bees:

The ANOVA determined there were no significant "trial" or "trial by treatment" differences, at a 95% confidence level, but that there was a significant difference between the four treatments (Table 4.1.). The Student-Newman-Keuls analysis of treatments indicated a tiered response had occurred where each dose was only associated with its neighbouring treatments. (Table 4.2.). This is where the control counts were similar to treatment 1, the latter was similar to treatment 2, and treatment 2 was similar to treatment 3. The graphs of the daily counts of dead bees (Fig. 4.3.) show that treatment colonies 2 and 3 were immediately affected by the methyl parathion but these high dead bee counts only occurred during days 4 to 6 whilst the methyl parathion was present. This suggests that because the volatiles were being removed by the vacuum system, very little residual methyl parathion remained once the filter paper was removed. Because the number of dead bees was more than 1000 for the medium and high doses, the behaviour of the low and control doses was masked. A second graph without results from the high and medium doses showed that the low dose caused lower mortality than seen in the controls.

Table 4.1. ANOVA of the dead bee count data that were normalised using a square-root transformation.

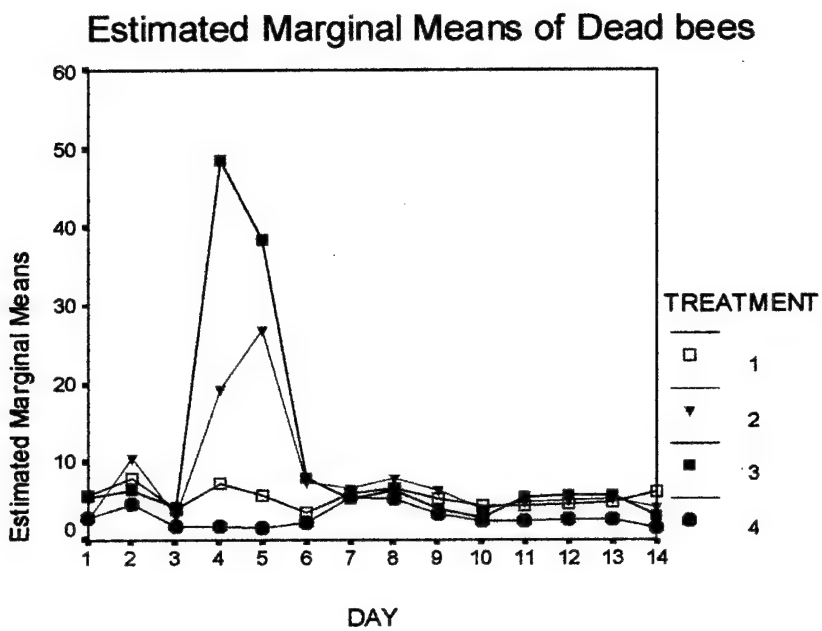
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	9770.278	1	9770.278	468.395	.000	468.395	1.000
Treatment	1340.409	3	446.803	21.420	**.016**	64.260	.916
Trial	121.622	2	60.811	2.915	**.198**	5.831	.247
Treatment by trial	46.443	6	7.740	.371	**.861**	2.227	.076
Error	62.577	3	20.859				

[a] Computed using alpha = .05

Table 4.2. Student-Newman-Keuls analysis of dead bee counts that groups the means for treatments in homogenous subsets.

	Treatment	N	Subset		
			1	2	3
Student-Newman-Keuls	4	6	3.9712		
	1	3	5.7014	5.7014	
	2	3		8.6219	8.6219
	3	3			10.2396
	Sig.		0.160	.052	.181

Figure 4.3. Dead bee counts from the honey bee colonies that were dosed with methyl parathion throughout the three trials. The colonies were dosed on day 3. Treatment 1 was 0.11kg/hectare of methyl parathion, treatment 2 was 0.56kg/hectare, treatment 3 was 1.1kg/hectare of methyl parathion and treatment 4 was the control.



Treatment	Standard Error of the flight Activity values for each day													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.3	.6	1.4	.9	.4	.4	.2	.9	.8	2.8	1.7	1.1	.6	.8
2	1.4	1.7	1.3	2.4	.4	4.0	1.7	1.2	1.5	1.9	1.8	.9	.2	.8
3	.8	.6	.9	8.1	2.3	10.1	1.2	.8	1.9	1.2	.9	1.3	1.7	.9
4	1.3	.9	.6	1.1	.8	.6	.7	.9	.5	1.2	.7	.8	.7	.7

Flight activity:

The ANOVA for the scaled flight data determined that there was no significant trial or treatment effects (Appendix 5.B.i.). However, the non-significance for the treatment effect was only slight, as the p-value was 0.051 at the 95% confidence level, and from the graph this can be attributed to the inconsistent flight activity displayed by the controls (Appendix 5.B.ii.). To determine the significance of the treatment effects, the trials were removed by treating them as experimental replications. A second ANOVA (Appendix 5.B.iii.) revealed there was a significant difference between the treatment effects because the p-value was 0.014 at the 95% level of confidence. However, the graph was still confounded by the inconsistent control data (Appendix 5.B.iv.), so the

last step was to remove the control and compare the flight activity from each of the treated colonies. Once the trials and controls were removed, the final ANOVA (Table 4.3.) showed the treatments were significantly different with a p-value of 0.005 at the 95% confidence level. The Student-Newman-Keuls analysis (Table 4.4.) supported this and showed that the high treatment effects differed from the low and medium treatment effects which was also seen in the graph (Fig. 4.4.).

Table 4.3. ANOVA of the scaled flight data from the 1999 methyl parathion experiments with pooled trial data, but no control data.

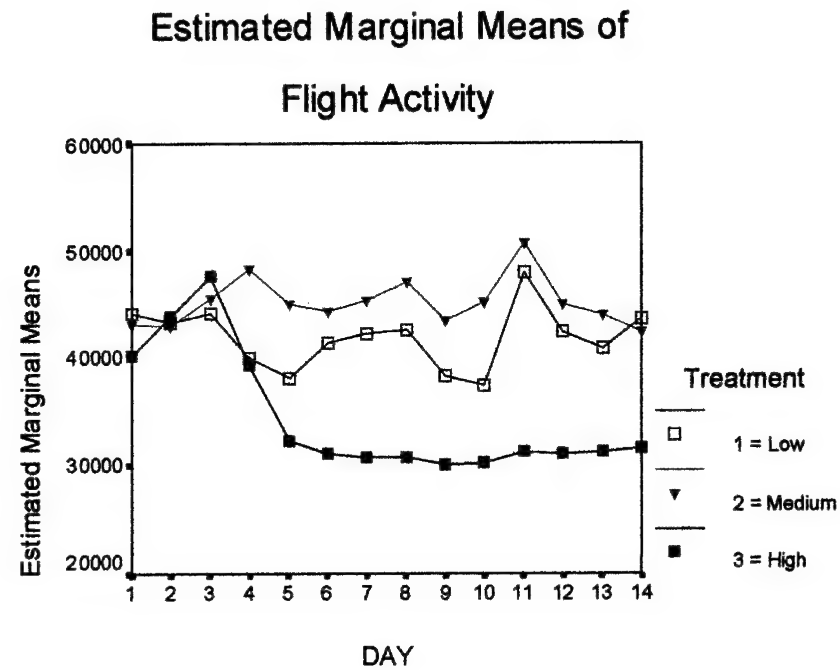
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	2.07×10^{11}	1	2.07×10^{11}	2393.426	.000	2393.426	1.000
Treatment	2.54×10^{9}	2	1.27×10^{9}	14.665	**.005**	29.330	.962
Error	5.19×10^{8}	6	86579559 (6.8%)				

[a] Computed using alpha = .05

Table 4.4. Student-Newman-Keuls analysis of the scaled flight data from the 1999 methyl parathion experiments, excluding trials and controls, that groups the flight data means for treatments in homogenous subsets.

			Subset	
	Treatment	N	1	2
Student-Newman-Keuls	3	3	34489.794	
	1	3		41957.690
	2	3		45214.151
	Sig.		1.000	.160

Figure 4.4. Scaled flight activity data from the 1999 methyl parathion experiments, with pooled data trial and no control data. T1 is flight data from the colonies dosed with 0.11kg/hectare of methyl parathion, T2 is the 0.56kg/hectare dose data, and T3 are the 1.1kg/hectare dosed colonies. Dose day was day 4.



Treatment	Standard Error of the flight Activity values for each day													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1441	491	1296	789	821	4126	910	1890	5619	6078	4282	1599	2953	7834
2	599	699	1298	2316	1475	2062	1341	2323	714	1896	443	2342	1924	876
3	4318	643	3790	3738	3488	3198	2103	2124	2742	2616	1691	1763	1616	1325

Percent Return:

The ANOVA states there is a significant "treatment" effect, a possible "trial" effect and no "treatment by trial" effect (Table 4.5.). The trials were selected to be pooled despite the 0.05 level of significant difference because the confidence intervals slightly overlapped (Appendix 5.C.ii.), and all three trials were grouped separately from controls, by the Student-Newman-Keuls analysis (Table 4.6) and supported by the Sidak test (Appendix 5.C.iii). The barely significant trial effect resulted from a hurricane that occurred during trial 3, seven days post-treatment, which reduced the flight activity of all the colonies. As previously mentioned, LSD is a sensitive test so it identified this difference between trials 1 and 2. The Student-Newman-Keuls

analysis (Table 4.7.), and the LSD test (Appendix 5.C.iv.) both showed treatment 3 was significantly different to treatments 1 and 2, as well as the control.

Forager return declined on dose day 4 for all colonies treated with methyl parathion (Fig 4.5.). The percent return for the low dosed colonies returned to normal by day 5, whereas the medium dose produced an intermediate response. This returned to normal by day 7 but may have weakened the colonies as they were affected by a subcritical perturbation on day 12. The number of returning bees from the high dosed colony dramatically declined, then increased on day 7, but dropped again on day 8. The forager force appeared to weaken as the perturbation on day 12 caused the return rate to decline below that caused by the dose.

Table 4.5. ANOVA of the percent return data that were normalised by an arcsine-square root transformation.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	346.266	1	346.266	3937.954	.000	3937.954	1.000
Treatment	4.991	3	1.664	18.920	**.019**	56.760	.885
Trial#	1.668	2	.834	9.484	**.050**	18.967	.608
Treatment by trial#	4.204	6	.701	7.969	**.058**	47.814	.594
Error	.264	3	8.793E-02				

[a] Computed using alpha = .05

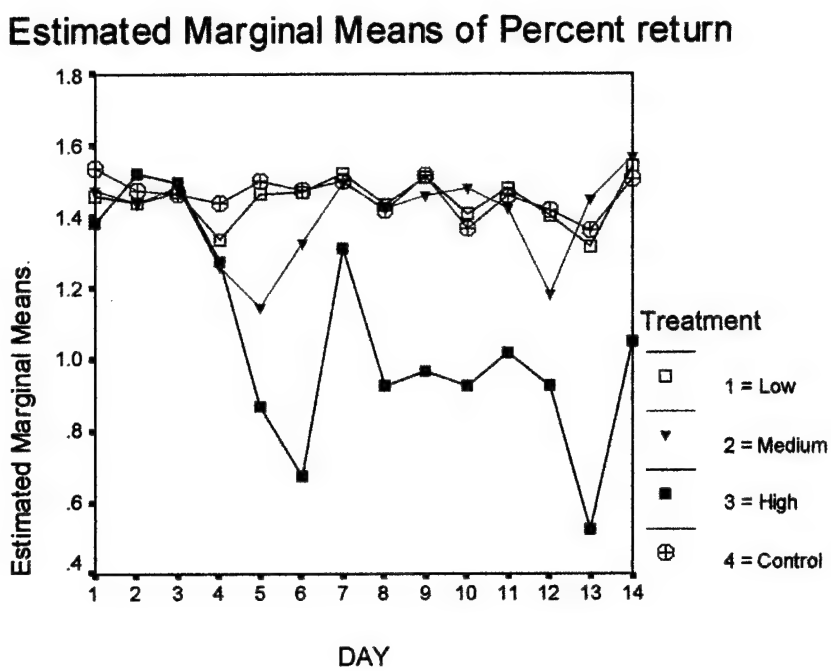
Table 4.6. Student-Newman-Keuls analysis that groups the Percent Return means for trials in homogenous subsets.

	Trial:	N	Subset 1
Student-Newman-Keuls	2	5	1.2699
	2	5	1.3663
	1	5	1.4632
	Sig		.061

Table 4.7. Student-Newman-Keuls analysis of percent return data that groups the Percent Return means, for treatments, in homogenous subsets.

	Treatment	N	Subset 1	Subset 2
Student-Newman-Keuls	3	3	1.0612	
	2	3		1.4020
	1	3		1.4480
	4	6		1.4606
	Sig.		1.000	.642

Figure 4.5. Percent return data from the colonies dosed with 0.11, 0.56 and 1.1 kg/hectare of methyl parathion. Dose day for the three trials was day 4. The perturbation at days 12-13, in trial 2, was due to hurricane Floyd.



Treatment	Standard Error of the Percent Return values for each day													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 = 0.11	.11	.07	.06	.01	.05	.06	.05	.07	.06	.09	.05	.08	.04	.03
2 = 0.56	.10	.00	.04	.03	.01	.12	.07	.10	.06	.05	.02	.25	.06	.00
3 = 1.1	.18	.06	.04	.03	.18	.15	.26	.47	.48	.47	.51	.47	.52	.52
4 = Control	.02	.04	.04	.04	.04	.05	.04	.05	.03	.06	.04	.03	.06	.04

Colony composition:

The composition of the colonies were recorded for at least three weeks for each trial. Only changes in brood data were analysed which revealed that the trials were not significantly different at a 95% confidence level (Appendix 5.D.i). However, because the queens from trial 3 had ceased laying in preparation for winter, data collection was limited to three weeks. This did not produce extensive enough data for appropriate analysis (Appendix 5.D.ii.), so trial 3 was disregarded which enabled only five weeks of post-treatment brood data from trial 1 and trial 2 to be analysed.

The ANOVA and Student-Newman-Keuls analysis of pooled data from trials 1 and 2 determined there was no significant difference between treatments (Table 4.8. & Table 4.9.). However, the brood composition graph (Fig. 4.6.), infers that treatments 1 and 4 colonies may differ from treatment 2 and 3 colonies. This is observed from the decline of brood numbers from treatment 2 and 3 colonies after week 2, whereas the amount of brood in the treatment 1 and 4 colonies was fairly consistent.

The brood composition analysis of the test-colony used to determine the doses of methyl parathion, revealed that the total amount of brood declined one week post-treatment (Fig. 4.7.). This response to a 0.56kg/hectare dose of methyl parathion was caused by a combined decline of capped brood and larvae. Conversely, the amount of eggs slowly increased during weeks one to five.

Table 4.8. ANOVA for five weeks brood data from trials 1 and 2.

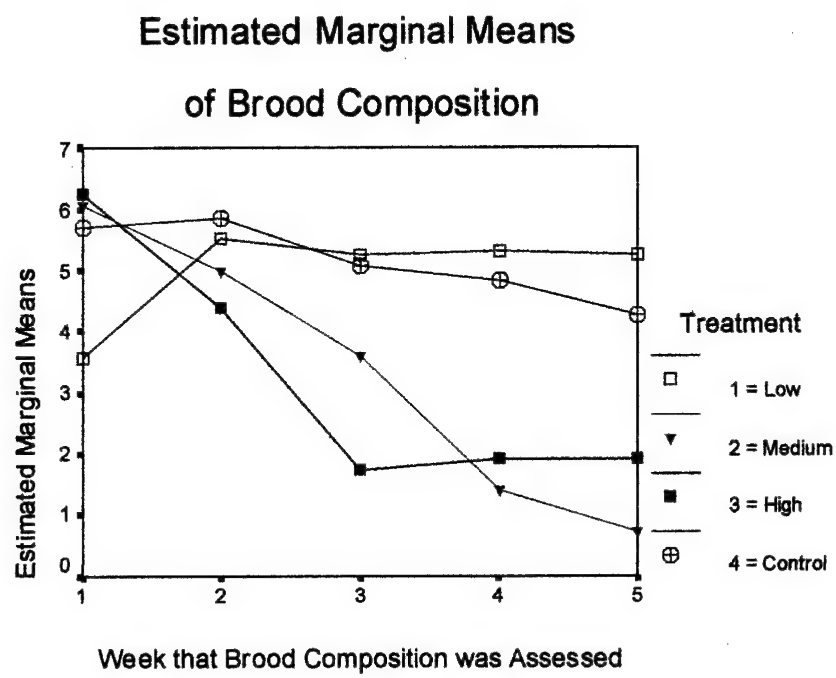
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	801.413	1	801.413	162.637	.000	162.637	1.000
Treatment	39.065	3	13.022	2.643	**.144**	7.928	.381
Error	29.566	6	4.928 (37.8%)				

[a] Computed using alpha = .05

Table 4.9. SNK analysis of five weeks brood data from trials 1 and 2.

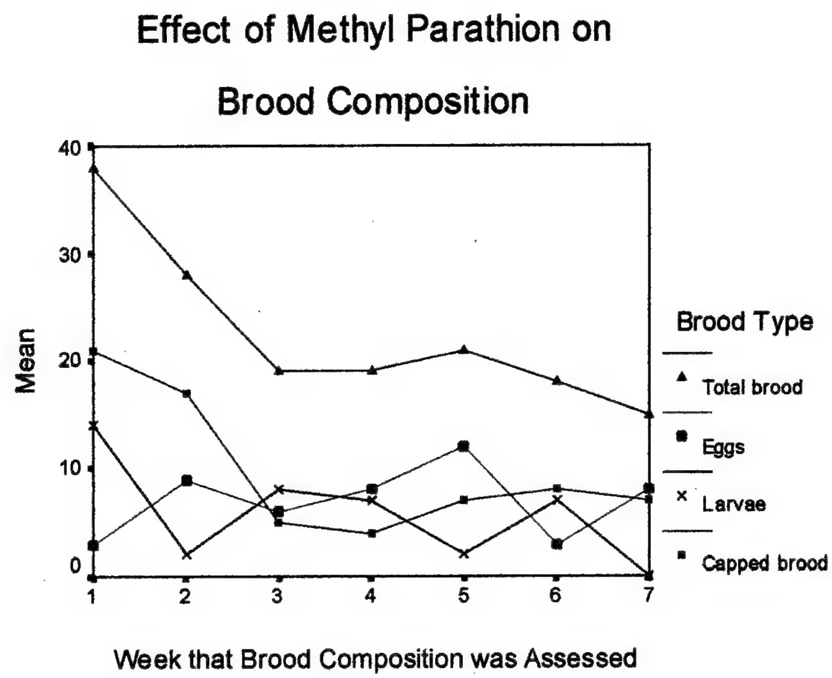
	Treatment	N	Subset 1
Student-Newman-Keuls	3	2	3.2444
	2	2	3.3584
	1	2	4.9905
	4	4	5.1547
	Sig.		.267

Figure 4.6. Brood composition data from trials 1 and 2. The colonies were dosed between weeks one and two with 0.11, 0.56 and 1.1 kg/hectare of methyl parathion..



Treatment	Standard Error of the Brood for each week				
	1	2	3	4	5
1	2.58	0.05	0.90	1.08	1.14
2	0.08	1.55	1.73	1.94	1.94
3	0.12	0.11	0.19	0.52	0.89
4	0.41	0.1	0.14	1.42	0.71

Figure 4.7. Brood composition data from the colony that was used to establish the range of methyl parathion to be used for this experiment. The colony was dosed between weeks 1 and week 2 with 0.56 kg/hectare of methyl parathion.



General results:

The colony treated with 0.56kg/hectare of methyl parathion in trial 1 and the colony treated with 1.1kg/hectare in trial 2, absconded as a result of treatment.

DISCUSSION

Dead bee counts:

The tiered dead bee response supports the use of dead bee counts to indicate an immediate effect of methyl parathion on a colony. However, it suggests that the usefulness of this parameter is reduced once the treatments were removed from the colonies as the extraction of methyl parathion volatiles prevented the residues from accumulating within the hive.

Moffett *et al.* (1983) and Estesen *et al.* (1992) observed bee mortality that was 100 times greater than pre-treatment counts during the three days post-treatment, when the methyl parathion in the field degrades to <5% of the initial deposit (Bennett *et al.* 1990). Their results were similar to what occurred in this study immediately after treating the colonies with high and medium doses of methyl parathion, where the dead bee counts were high and then decreased to normal once the methyl parathion had been removed.

Collecting dead bees from the front of the hive was of little value because it was only a small proportion of the number of dead bees collected from within the hive. This was expected as Atkins *et al.* (1977) also found them to be of little value. This is why the number of dead bees collected from each hive were combined for the analysis.

Flight activity:

The counts of incoming and outgoing bees were a useful indicator of flight activity and enabled the progression of colony recovery to be monitored. Flight activity of the colonies dosed with methyl parathion was significantly reduced and did not return to pre-dose levels throughout the duration of this experiment. This indicates that the colonies did not fully recover within the two weeks. Insecticides are known to reduce pollen gathering and crop visitation (Todd & Reed 1969, Johansen *et al.* 1990), but until now the duration of effects has not been quantified. These data identify that foraging was reduced for two weeks post-treatment. However, further analysis by this system would enable a more accurate quantification to be made.

These results indicate that the effect of methyl parathion on the colony lasts longer than the duration of exposure. This is because the colony has to recover from the impact of losing a large percentage of the foraging force. The "real time" component of this parameter enables a daily pattern to be established and can identify the effect of a toxic event within an hour. This is important for future research because geographic regions predominantly have varying climates, which alters flight activity (Johansen 1977, Bromenshenk pers.comm.). By identifying a colony's usual flight activity, safe times to spray can be determined (Johansen *et al.* 1990). "Real time"

data enables this sort of information to be gathered and used so as to reduce the effects of pesticides on honey bee foraging, which ultimately impacts pollination.

Percent return:

Percent return is able to indicate the immediate effect of methyl parathion on a colony because it determines the number of bees that do not return during the day. It does not enable the decline in forager force to be seen in relation to time. However, when return rates are coupled with flight data the forager loss can be quantified, and when combined with the classic dead bee counts, the total loss of bees from the colony can be calculated per day. It is a useful parameter to quantify damage that may have occurred to a colony as the result of pesticide spraying.

Colony composition:

Changes in colony composition occurred too slowly to indicate the immediate effects of pesticides on the colony. However, it is useful for determining whether the colony would be able to recover. In this study the queens egg-laying inertia partially masked brood mortality by compensating for forager losses. This is consistent with previous research (Sanford 1983), as was the reduction in the size of the brood nest, which occurred a couple of days after treatment in response to the decline of nurse bees that had replaced the dead foragers.

Colonies that have large reserves of capped brood and recently emerged bees are able to replace the lost foragers quickly by using these young bees to forage before the usual three weeks of age (Sanford 1983). Individual bees can change their tasks according to the needs of the hive and this appears to have little or no effect on the colony (MacKenzie *et al.* 1989). However, if the queen has reduced her laying rate so there is only a small reserve of brood in the hive, as in trial 3, it may take more than six weeks to recover, if at all, depending on the season.

A colony with abundant food reserves will also survive poisoning better than one without reserves. The reserves within the hive can sustain the colony during this crucial period, rather than the bees being forced to use up energy by collecting food,

which may not be easily available. Colonies from trial 3 were treated in autumn after the main nectar-flow had subsided. This resulted in the treated colonies using up their food supplies and subsequently being unable to replenish them. The colonies in trial could not sustain themselves through winter, which resulted in hive annulment. This suggests that if a colony has been exposed to pesticides, it is important to ensure there are ample food supplies for them to raise replacement brood. Harbo (1993a) determined that the weight of brood was 75% of the weight of the honey it took to produce it, and that 121g of honey was required to produce 1000 cells of mixed-aged brood.

The size of a colony alters its dynamics because bee density effects honey loss, adult survival, and brood production (Johansen *et al.* 1990, Harbo 1993b). Colonies with large populations may have an increased chance of survival from pesticides, as long as there is space to produce more brood to compensate for loss of foragers. If this is the case, then it may be inappropriate to extrapolate results obtained from a nuc containing 15,000 bees to full-size colonies (45,000-60,000 bees). However, results from the smaller colonies do provide data which are testable in the larger colonies.

General Comments:

The two colonies that absconded during trial 1 and 2 exhibited typical behaviour of disturbed colonies. Absconding is primarily characteristic of tropical *Apis* races (Fletcher 1978), but occurs both seasonally and when the quality of the hive deteriorates by predation, fire, pests, over-heating, or pesticides (Fletcher 1975, Winston *et al.* 1979, Schneider 1990). Brood rearing in absconding colonies is greatly reduced (Fletcher 1975, Woyke 1976, Winston *et al.* 1979, Thoenes *et al.* 1992), but it is unknown whether this is due to the diminished laying activity of queens, or brood cannibalism by workers. This study recorded brood composition up until the colonies absconded and supports the idea that cannibalism reduces the amount of brood. This is seen from brood decreasing from approximately four to two sides of a frame per colony. Absconding increases the chance of survival for a disturbed colony but the associated time and energy required to find a new location, make the flight, and then produce wax to build combs, is costly (Otis *et al.* 1981, Hepburn 1988, Schmidt 1995).

The position of our hives may have had an effect on colony recovery because tree coverage caused some hives to receive less light than others. The position of hives has an unknown effect on the accumulation and impact of pesticides and their foraging behaviour.

In 1981, Hoopingarner *et al.* were the first to visually quantify pesticide contamination from dead bees. The result of these experiments are the first to quantify flight activity that occurs as a result of pesticide contamination.

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SYNTHESIS

This thesis supports the comprehensive pesticide research that has been conducted by Johansen and Mayer (1990) regarding the effects of pesticides on honey bees, and extends it by using "real time" flight activity and forager return rates to quantify these effects. When "real time" flight data are coupled with dead bee counts and colony composition, the short and medium term effects of toxic events on honey bee colonies can be locally established and used to determine when pesticides should be applied, as well as enabling the impact upon pollination to be extrapolated.

Data from chapter 2 and chapter 4 of this thesis support Johansen (1977) who suggests that the climate of a geographical location alters the daily flight pattern of honey bees, which consequently determines the safest time of day to spray (Johansen & Mayer 1990). The "real time" component of the electronic system used in this thesis, enables timely data to be gathered for the reduction of pesticide effects on foraging honey bees, and accurately monitors colony recovery. Monitoring a colony after it has been exposed to pesticides is beneficial because the state of a colony determines whether it can continue to be used for bio-monitoring, pollination, and honey production.

Although the immediate effects of pesticides are of concern, long term effects can be devastating as these impact pollination, and ultimately crop yield. Because science is often regarded as a means to increase the economy, it is the application of this "real time" system that will aid future research. However, to achieve this result, it will be necessary to increase the accuracy of the flight data gained from honey bee colonies by decreasing the large standard error seen in these experiments. This can be achieved by gathering data from colonies that are of commercial size and from a greater number of colonies.

Future research:

Irrespective of the hazard of insecticides to beneficial insects, the use of pesticides in crop management will invariably be supported (Pendergrass *et al.* 1992) because the

economic return of a crop is of primary importance. Further research into both bee behaviour and pesticide application methods will therefore be essential in order to reduce the risk to honey bees.

Electronic data collection has been demonstrated in this thesis to support measurement of the effects of pesticides on the hive dynamics of honey bees. It also provides a way for scientists and beekeepers to identify their colonies flight activity and determine which colonies would be effective for pollination, or of similarly matched activity for research purposes. An example of this would be the ability of Hort Research in New Zealand to use flight activity to determine which honey bee colonies would be effective vectors to spread the suggested biological pathogen to control fireblight (*Erwinia amylovora*) (Hort Research 1998). The recorded flight activity may also lead to an increased understanding of how fast, or otherwise, the spread of this pathogen may occur.

The response of house bees to pesticides in the hive is another behavioural dynamic that is of research interest. Chapter 3 showed that forager bees did not avoid contact with methyl parathion 30 minutes after exposure. To determine whether house bees display similar avoidance behaviour or if they cluster around the contamination, the spatial distribution of a colony within a hive could be reviewed. The University of Montana has designed a bee hive with 96 temperature probes that may be able to identify the distribution of those bees affected by pesticides, by the localised heat emitted from the bees.

The usefulness of a honey bee monitoring system is also relevant to commercial beekeepers because they require the status of their colonies to be monitored on a large scale basis. The electronic collection of colony flight data significantly reduces the time needed to assess a colony's status because the colony does not need to be physically checked, and it also reduces the consequences that result from "working[1]" a colony, such as dead bees.

[1] Physical inspection of a hive to establish colony status. Achieved by removal and inspection of individual frames.

Further research that would also benefit a commercial beekeeping operation would be the development of a device, associated with the current monitoring system, that could detect the queens location and health, because a weak queen reduces the productivity of a colony, which in turn reduces crop yield. Because workers tend the queen it is possible that the development of miniaturised thermistor transmitters may aid this detection[2].

An area associated with pesticide use that is in need of review is pesticide labelling. Pesticide labels provide application instructions that suggest that early morning or late evening are the best times of day to apply in order to avoid periods of bee foraging. However, it is questionable whether this actually protects honey bees because, as previously mentioned, flight activity varies between regions: In Missoula, Montana, United States of America, a honey bee colony is active from 6am to 10:30pm in summer where the flight activity peaks around 1pm, whereas bee colonies in Maryland, USA, have two flight peaks, one around 10:30am and one around 2:30pm (Bromenshenk pers. comm.). This suggests that pesticide labelling is too general and that targeted application instructions need to be developed for specific locations depending on the flight patterns of that area. Knowledge is a key resource, whether employed now or in the future, so by collecting flight data from different regions further research can start to identify pesticide effects on the colony dynamics and compare regional honey bee flight patterns in order to integrate them into crop and pest management.

[2] I proposed this idea during my work with Dr. J. Bromenshenk at the University of Montana, who is currently investigating the use of miniature transmitters for forager bee tracking.

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APPENDICES

Appendix 1)

Vapour Density of Methyl parathion

Density of air as a reference of 1.

At room temperature 1 mol occupies 24.4L

Air: $\frac{28.96g}{Mol_{(air)}} \times \frac{1mol}{24.4l} = \underline{\mathbf{1.18g/l}}$

Where N2 78% (28g) + O2 21% (32g) + Argon 1% (39.9g)

0.78 x 28 + 0.21 x 32 + 0.01 x 39.9

Methyl parathion: 11.87 x 9.1 = 10800.7g/m3

= **10.8g/l**

Ratio 1.186g air : 10.8g methyl parathion

Density of methyl parathion in relation to air is **9 times** ie: **1 : 9.1**

Appendix 2)

Beetox – Computer program that details the effects of pesticides on honey bees.

Mortality Rate %	**Pesticide concentration** (*ug*/bee)
2	0.14
10	0.18
15	0.19
17	0.20
20	0.21
25	0.22
30	0.24
46	0.28
50	0.29
54	0.30
65	0.34
75	0.38
81	0.40
86	0.44
91	0.48
92	0.50
95	0.54
97	0.58
98	0.60
100	0.66

Appendix 3)

Methyl Parathion calculations

0.5lb/acre dose: 1 acre = 4840yd^2

= 43560ft^2 (1yd^2 = 9ft^2)

= 6272640 inches^2 (1ft^2 = 144in^2)

1kg = 2.2lb therefore 0.5/2.2 = 0.22727272 kg/acre

= 0.2272 kg/6272640 inches^2

= 3.6232388x10^{-8} kg/inches^2

= 3.6232388x10^{-2} mg/inches^2

Size of Application board: 10.5625 x 7.5625 inches = 79.87890625 inches^2

= 5153mm^2

Mg/board required to deliver a 0.5lb/acre dose: 3.6232388x10^{-2} x 79.87890625

= 2.8942035 mg/board

Pipette volume = 20ml

To make a stock solution of 0.5lb/acre with 250mg Methyl parathion in methanol:

2.89mg/20ml = 250mg/*x*methanol therefore

(*x*methanol/250mg) x 250mg = (20ml/2.89mg) x 250mg

= 1.7271

<u>250mg Methyl parathion in 1.7271 methanol</u>

To make a 0.11lb/acre solution from the 0.5lb/acre stock solution:

Factor = c2/c1 = 0.5/0.11 = <u>4.545</u>

c2/c1= v1/v2 To make v1 = 90.9ml

Take 20mL 0.5lb stock solution and add (20ml x 4.545) = 70.9ml methanol

Appendix 4)

Observations made from experiments that dosed honey bees with methyl parathion, at Montana University, 1998.

Experiment 1: Effects of methyl parathion consumption by honey bees.

Methyl parathion was mixed with methanol (50mg/1ml) and 100mg aliquots were put into an 11g ball of Crisco and sugar mixture (1.25:1 ratio) that was inside a folded packet of unbleached filter (dimensions height 5cm, top width 12.7cm, base 5cm. Each packet contained 3 slits in the side and the top was stapled over. The packets were hung on a wire that was placed over a nail on top of the brood nest frames in the bottom hive body.

When methyl parathion was positioned between the brood frames, a stinging response was stimulated. On removal of the "100 mg" Crisco patties, 10-15 stingers were found attached to them. This suggests high levels of pesticide may kill in two ways, by expected fumigation, and secondly, by eliciting a stinging response which results in their death. This may suggest that it is not just suffocation from the pesticide that causes the death but the honeybees response to a foreign vapour.

When the methyl parathion was placed in the hive a large proportion of bees evacuated and hung in a cluster on the door of the condo. The counters showed the unusual behaviour of movement out of the hive after dark, during the residue tests. This suggests that honey bees deisplay behavioural flexibility.

Experiment 2: Does methyl parathion elicit a stinging response by honey bees?

Analysis of previous experiment 1 revealed bees had stung the filter packets used to hold the methyl parathion, and left their stingers in the paper.

Two manifold systems, each consisting of three single Plexiglass frames in succession, were set up, and the bees response to contact with methyl parathion was recorded over a three hour period.

The first run was conducted on 4th December 1998. There was a control manifold, and a treatment manifold that dosed all three hives with 10mg methyl parathion. The dose was mixed with 160μl of methanol to scale it down from 250mg : 4000μl.

A 20.0g filter packet of 1.25 : 1 ratio of sugar and Crisco was placed in the middle of each frame in both manifold systems, for three hours. The experiment was conducted inside a plastic room because the bee colonies had shut down for the winter. The methyl parathion vapours were dispersed through the frames using the CPVC airflow system, which pulled the air through the manifold across the lowest to the highest dose respectively, and then out through an organophosphate/ pesticide filter into a vacuum.

After three hours, the number of dead bees and the number of stings in each packet were counted and the mortality was used as a final measure of the effects that methyl parathion has on honey bees.

The second run used one manifold as the control and dosed the second manifold with packets containing 10, 20 and 50mg of methyl parathion.

The results were unable to confirm the observations first made in experiment 1 but it would be interesting to redo these experiments when the bees are still physiologically active in the field.

Experiment 3: Fight or flight response of honey bees to methyl parathion

Four frames of bees were placed in a sealed Plexiglas hive and left to acclimatise. A clear, 60cm tube was attached to the hive entrance and joined to a second empty Plexiglas

hive. A 20.0g packet of 1 : 1.25 ratio of Crisco : sugar, was combined with 50mg methyl parathion mixed in 1.6ml methanol. The packet was placed in the middle of the hive for 3hrs whilst the bees behaviour was observed and then the number of dead bees in each section were counted. After dosing the colony the entire hive was dead within three hours and only a few were situated in the plastic tube. The bees had not moved in to the undosed plexiglass hive but this may be because they did not have long enough to acclimatise and consequently did not realise they could escape from the hive. Repeating this experiment with colonies that were acclimatised to the Plexiglas hives may lead to more extensive results.

Appendix 5)

Analysis made for the four parameters of Chapter 4: The effects of methyl parathion on the colony dynamics of *Apis mellifera*

A) Dead Bee ANOVA:

Multiple Comparisons

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
LSD	1	2	-2.9205	.9966	.061	-6.0923	.2512
		3	-4.5382	.9966	**.020**	-7.7099	-1.3664
		4	1.7302	.8631	.139	-1.0166	4.4770
	2	1	-2.9205	.9966	.061	-.2512	6.0923
		3	-1.6177	.9966	.203	-4.7894	1.5541
		4	4.6507*	.8631	**.013**	1.9039	7.3975
	3	1	4.5382*	.9966	**.020**	1.3664	7.7099
		2	1.6177	.9966	.203	-1.5541	4.7894
		4	6.2684*	.8631	**.005**	3.5216	9.0152
	4	1	-1.7302	.8631	.139	-4.4770	1.0166
		2	-4.6507	.8631	**.013**	-7.3975	-1.9039
		3	-6.2684	.8631	**.005**	-9.0152	-3.5216
Sidak	1	2	-2.9205	.9966	.314	-9.0845	3.2435
		3	-4.5382	.9966	.113	-10.7022	1.6258
		4	1.7302	.8631	.592	-3.6080	7.0684
	2	1	2.9205	.9966	.314	-3.2435	9.0845
		3	-1.6177	.9966	.744	-7.7817	4.5463
		4	4.6507	.8631	.073	-.6875	9.9889
	3	1	4.5382	.9966	.113	-1.6258	10.7022
		2	1.6177	.9966	.744	-4.5463	7.7817
		4	6.2684*	.8631	**.032**	.9302	11.6066
	4	1	-1.7302	.8631	.592	-7.0684	3.6080
		2	-4.6507	.8631	.073	-9.9889	.6875
		3	-6.2684	.8631	**.032**	-11.6066	-.9302

Based on observed means.
* The mean difference is significant at the .05 level.

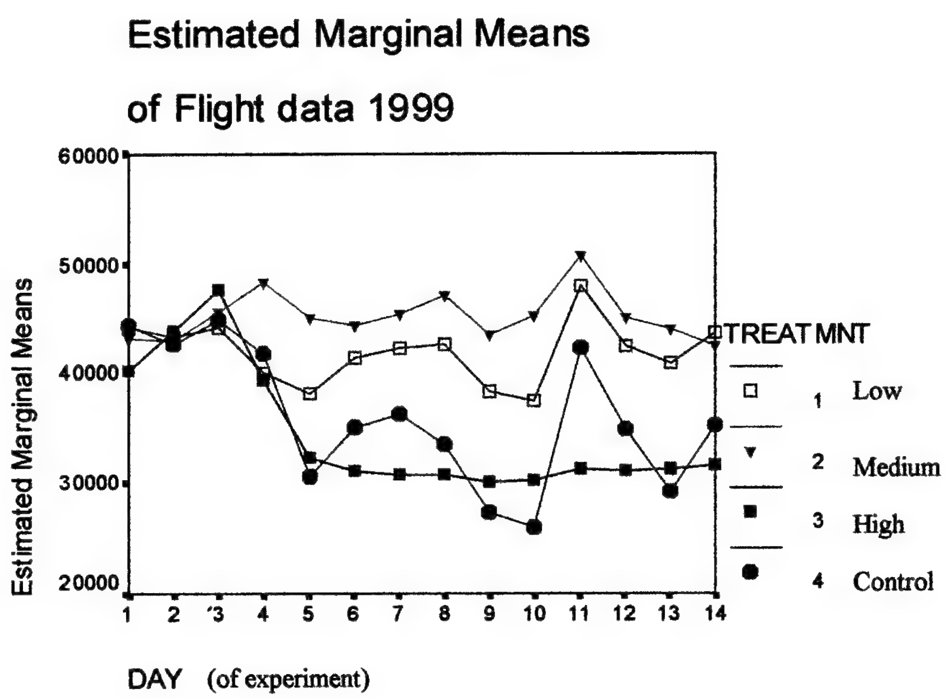
B) Flight data

i. ANOVA of the scaled 1999 flight data.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	2.98×10^{11}	1	2.98×10^{11}	2285.495	.000	2285.495	1.000
Treatment	3.57×10^{9}	3	1.19×10^{9}	9.115	**.051**	27.344	.618
Trial	1.13×10^{8}	2	56327252	.431	**.684**	.863	.078
Treatment by trial	1.56×10^{9}	6	2.6×10^{8}	1.994	**.305**	11.965	.200
Error	3.92×10^{8}	3	1.31×10^{8}				

[a] Computed using alpha = .05

ii Flight data from the 1999 methyl parathion Experiments. T1 = Low dose, T2 = Medium dose, T3 = High dose, T4 = Control

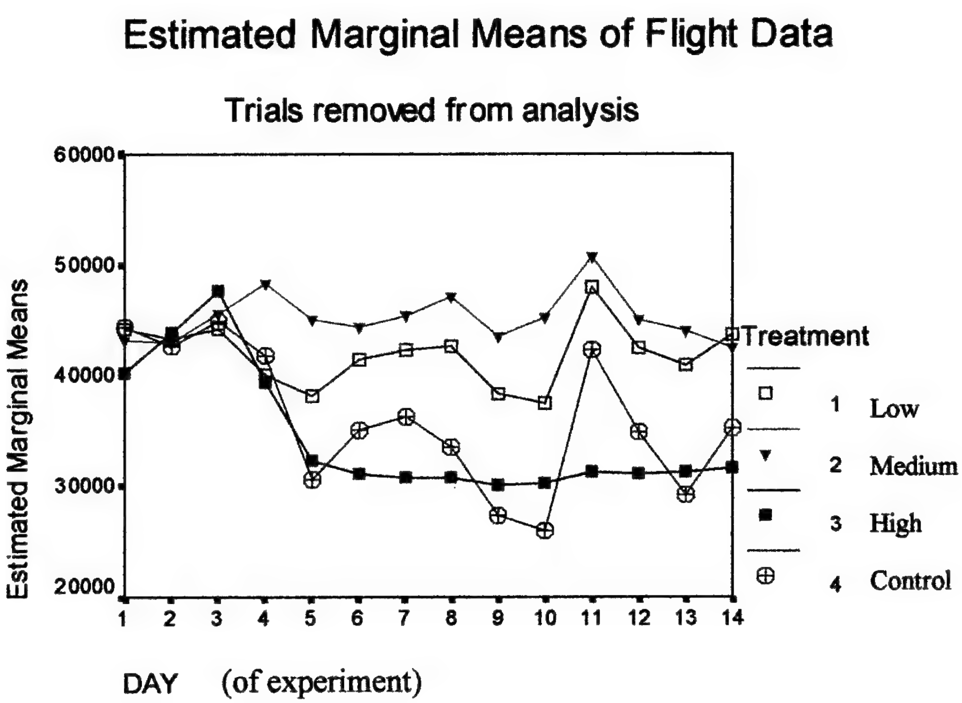


iii ANOVA of the 1999 scaled flight data where the trials are pooled.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	2.98×10^{11}	1	2.98×10^{11}	1408.454	.000	1408.454	1.000
Treatment	3.57×10^{9}	3	1.19×10^{9}	5.617	**.014**	16.851	.831
Error	2.33×10^{9}	11	2.12×10^{8}				

[a] Computed using alpha = .05

iv Flight data from the 1999 methyl parathion experiments with trials pooled for analysis. The colonies were dosed on day 3.



C) Percent return Analysis:

i) Confidence Intervals for treatment analysis

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	1.448	.046	1.302	1.594
2	1.402	.046	1.256	1.548
3	1.061	.046	.916	1.207
4	1.461	.032	1.358	1.564

ii) Confidence Intervals for trial analysis

	Mean	Std. Error	95% Confidence Interval	
TRIAL#			Lower Bound	Upper Bound
1	1.450	.037	1.332	1.568
2	1.223	.037	1.105	1.341
3	1.356	.037	1.238	1.474

iii) ANOVA comparing trial differences.

Multiple Comparisons

	(I) TRIAL#	(J) TRIAL#	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
LSD	1	2	.1933	5.012E-02	.031	3.382E-02	.3528
		3	9.692E-02	5.012E-02	.149	-6.2589E-02	.2564
	2	1	-.1933	5.012E-02	.031	-.3528	-3.3822E-02
		3	-9.6411E-02	5.012E-02	.150	-.2559	6.310E-02
	3	1	-9.6924E-02	5.012E-02	.149	-.2564	6.259E-02
		2	9.641E-02	5.012E-02	.150	-6.3102E-02	.2559
Sidak	1	2	.1933	5.012E-02	.090	-4.8581E-02	.4353
		3	9.692E-02	5.012E-02	.383	-.1450	.3388
	2	1	-.1933	5.012E-02	.090	-.4353	4.858E-02
		3	-9.6411E-02	5.012E-02	.386	-.3383	.1455
	3	1	-9.6924E-02	5.012E-02	.383	-.3388	.1450
		2	9.641E-02	5.012E-02	.386	-.1455	.3383

Based on observed means.

* The mean difference is significant at the .05 level.

iv) ANOVA comparing treatment differences.

Multiple Comparisons

	(I)Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
LSD	1	2	4.606E-02	6.471E-02	.528	-.1599	.2520
		3	.3869	6.471E-02	.009	.1809	.5928
		4	-1.2541E-02	5.604E-02	.837	-.1909	.1658
	2	1	-4.6059E-02	6.471E-02	.528	-.2520	.1599
		3	.3408	6.471E-02	.013	.1349	.5467
		4	-5.8599E-02	5.604E-02	.373	-.2369	.1197
	3	1	-.3869	6.471E-02	.009	-.5928	-.1809
		2	-.3408	6.471E-02	.013	-.5467	-.1349
		4	-.3994	5.604E-02	.006	-.5777	-.2211
	4	1	1.254E-02	5.604E-02	.837	-.1658	.1909
		2	5.860E-02	5.604E-02	.373	-.1197	.2369
		3	.3994	5.604E-02	.006	.2211	.5777
Sidak	1	2	4.606E-02	6.471E-02	.989	-.3542	.4463
		3	.3869	6.471E-02	.055	-1.3348E-02	.7871
		4	-1.2541E-02	5.604E-02	1.000	-.3591	.3341
	2	1	-4.6059E-02	6.471E-02	.989	-.4463	.3542
		3	.3408	6.471E-02	.077	-5.9407E-02	.7410
		4	-5.8599E-02	5.604E-02	.939	-.4052	.2880
	3	1	-.3869	6.471E-02	.055	-.7871	1.335E-02
		2	-.3408	6.471E-02	.077	-.7410	5.941E-02
		4	-.3994	5.604E-02	**.034**	-.7460	-5.2810E-02
	4	1	1.254E-02	5.604E-02	1.000	-.3341	.3591
		2	5.860E-02	5.604E-02	.939	-.2880	.4052
		3	.3994	5.604E-02	.034	5.281E-02	.7460

Based on observed means.

* The mean difference is significant at the .05 level.

D) Brood composition Analysis:

i) ANOVA of the 1999 brood composition data.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Intercept	856.026	1	859.026	631.748	.000	631.748	1.000
Treatment	6.344	3	2.115	1.561	**.362**	4.682	.160
Trial	6.592	2	3.296	2.432	**.236**	4.865	.214
Treatment by trial	12.289	6	2.048	1.511	**.395**	9.069	.162
Error	4.065	3	1.355				

[a] Computed using alpha = .05

ii) Graph of brood composition from three weeks of data collected from the colonies dosed with 0.11, 0.56, and 1.1 kg/hectare of methyl parathion, and the control.